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DATA EXCHANGE STRATEGY

PART I - REVIEW OF DIGITAL DATA EXCHANGE TECHNOLOGY

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This report documents the first phase of a three phase effort directed towards developing a Navy digital data exchange strategy for CALS. The data exchange strategy task has been divided into three distinct parts. Part I is documented in this report and provides an overview of data exchange. It includes a discussion of data exchange concepts, a summary of current and potential future CALS standards, and a brief overview of selected industry approaches to digital data exchange. It is intended to provide the reader with a single reference source to become familiar with the area of data exchange/data exchange standards and related activities. This document will serve as a reference document to the Navy's Acquisition Guide for Program Managers.

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ABSTRACT

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EXECUTIVE SUMMARY

CALS is a DoD and Industry initiative to enable and accelerate the use and integration of digital technical information for weapon system acquisition, design, manufacture, and support. Through CALS, a transition from a paper intensive mode of operation to an automated and integrated mode is in progress. This is aimed at improving both the productivity and quality of the weapons system acquisition and logistics support process.

While DoD is developing the corporate plans and architecture to establish the overall direction of the CALS implementation strategy, each service is responsible for its own implementation. The purpose of this report is to provide support to OPNAV in the development of a Navy strategy for digital data exchange in support of the CALS initiative. This report documents the first phase of a three phase effort directed towards developing a Navy digital data exchange strategy for CALS. The data exchange strategy will be instrumental in the Navy approach to implementing CALS.

The data exchange strategy task has been divided into three distinct parts. Part I is documented in this report and provides an overview of data exchange. It includes a discussion of data exchange concepts, a summary of current and potential future CALS standards, and a brief overview of selected industry approaches to digital data exchange. It is intended to provide the reader with a single reference source to become familiar with the area of data exchange/data exchange standards and related activities. This document will serve as a reference document to the Navy's Acquisition Guide for Program Managers.

To provide a baseline for discussion in data exchange, this report introduces a number of data exchange concepts. The concepts presented include translators (direct, neutral, and flavoring), application subsets and protocols, and testing (loop, end-to-end, verification, and application validation).

Many organizations are presently creating and maintaining their data using electronic systems because of the gains in productivity and cost savings. These computer based systems have broad applications in CAD/CAM (Computer Aided Design/Computer Aided Manufacturing), and Electronic Publishing. A variety of different vendors developed these generic software systems and store the data created on their proprietary software systems in their own proprietary formats. The stored data represents computer based models, design, drawings, technical documentation, and manufacturing information. While the vendors proprietary format is designed for efficiency, files stored in the vendors own non-standard format cannot be read by or electronically transferred to another software system.

Standards and specifications are being developed by CALS to provide the common interfaces needed to improve Industry and DoD productivity and quality in both acquisition and logistic support in the interchange and efficient use of digital data. CALS phase I focuses on standards for digital interchange of technical information among dissimilar computer systems. Initial CALS standards are intended to enable the digital delivery of engineering drawings and technical manuals including illustrations. CALS phase II focuses on the standards needed to access and manage data within a distributed data base. MIL-HDBK-59, Computer Aided Acquisition and Logistic Support (CALS) Program Implementation Guide, is DoD's guidance document for the implementation of CALS. Each service is responsible for issuing implementation guidance of their own. MIL-HDBK-59 provides an overview of CALS and provides guidance on the use and delivery of digital data. Under that standard lies MIL-STD-1840A, Automated Interchange of Technical Information, which provides technical information on the specifications used in CALS, the packaging of the digital form, and basic concepts.

Current CALS data exchange standards/specifications are:

1. MIL-STD-1840A, "Automated Interchange of Technical Information"

2. MIL-D-28000, "Digital Representation for Communication of Product Data: IGES Application Subsets"

3. MIL-M-28001, "Markup Requirements and Generic Style Specification for Electronic Printed Output and Exchange of Text"

4. MIL-R-28002, "Requirements for Raster Graphics Representation in Binary Format"

5. MIL-D-28003, "Digital Representation for Communication of Illustration Data: CGM Application Profile"

Future standards will address data interchange in terms of both technical data elements and the life cycle functional applications that use the technical data. Future CALS data exchange standards are likely to include:

6. MIL-STD-1388-2B," Logistic Support Analysis Record"

7. PDES, Product Data Exchange Specification

8. EDIF, Electronic Data Interchange Format

9. VHDL, VHSIC Hardware Description Language

10. ODA, Office Document Architecture

A brief overview of selected industry approaches to digital data exchange is presented and is not intended to represent a complete description of any company's activities but rather to provide an insight into each company's recognition of the importance of digital data exchange and their approach to addressing the problem. The companies highlighted are McAir, Newport News Shipbuilding, Northrop Aircraft Division, and Westinghouse Electronic Systems Group.

Part II of this task will provide a summary and evaluation of current CALS-related on-going Navy data exchange activities, and Part III will develop an approach to the strategy for Navy digital data exchange.

1.0 DATA EXCHANGE OVERVIEW

1.1 INTRODUCTION

DoD and Industry are embarking on the Computer Aided Acquisition and Logistics Support (CALS) initiative to accelerate the use and integration of digital technical information for weapon system acquisition, design, manufacture, and support. Through CALS, a transition from a paper-intensive mode of operation to an automated and integrated mode is in progress. This is aimed at improving both the productivity and the quality of the weapons system acquisition and logistics support process.

Many organizations are presently creating and maintaining their data using electronic systems because of the gains in productivity and cost savings. These computer based systems have broad applications in CAD/CAM (Computer Aided Design/Computer Aided Manufacturing), and Electronic Publishing. A variety of different vendors developed these generic software systems and store the data created on their proprietary software systems in their own proprietary formats. The stored data represents computer based models, design, drawings, technical documentation, and manufacturing information. While the vendors proprietary format is designed for efficiency, files stored in the vendors own non-standard format cannot be read by or electronically transferred to another software system.

In many cases the use of vendor proprietary formats poses no problem to the user. As long as all organizations requiring the data are using the same software, accessing the data can be achieved effortlessly. But other departments within the company or other companies having dissimilar hardware/software may have a need to access the data. For example, a design engineer may create a part model which could be used by the reliability and maintainability engineers, by logistics support and analysis, by manufacturing and by technical publications for their own work. If these other departments use a non-homogeneous software system (different from the one on which the data was originally created), the data can either be re-entered manually or exchanged electronically using translators. A drawback to entering data manually is the introduction of errors as the data is re-entered, and the duplication of effort. When the transfer is infrequent and small (and the people re-entering the data are inexpensive), this can be a viable option. If the frequency and volume of data exchanged make this method prohibitively expensive, a decision is often made to transfer the data electronically.

1.2 DIRECT TRANSLATORS VS. NEUTRAL FILE TRANSLATORS

Once an organization has decided to exchange data electronically, a further choice must be made as to whether a

direct translator or a neutral file translator will be used. Both methods have advantages and disadvantages.

A direct translator allows the user to pass information directly from one software system to another, without an interim stop at a neutral file. This approach can be tightly coupled to the application being dealt with, because only two software systems are being considered and the exchange does not need to be kept general. This type of translator is usually highly efficient and can be a good short term approach to data exchange.

Descriptions of digital data exchange concepts presented in this data exchange overview section have general applicability, but are described in terms of Computer Aided Design (CAD) and the Initial Graphics Exchange Specification (IGES) in order to provide a focus for illustrative purposes.

The use of direct translators may result in additional software maintenance efforts as when the vendor releases a new version of the CAD system, the translation software will need to be updated because the translation software is dependent on the CAD software. This will result in additional costs for translation software modification and testing. Some vendors provide a software interface to access their databases, insulating the direct translator from some database changes. But others do not, which may lead to problems if the format of the internal database changes, and there is no guarantee that the format of the internal database will remain fixed. CAD systems are constantly improving, adding more features and new entities. These new entities must be added to the direct translator. Additional problems arise if translation is required between more than two systems. With the direct translation there are more translators to support than with neutral file format translation.

The exchange is a one step process, but two translators are needed for every software system involved in the exchange. One translator to send data to the other receiving software system and

another to get data back. The example given in Figure 1 of four different software systems would require twelve translators to be written; two translators between each software system shown. If there are five systems, the number of translators required goes up to twenty. For n systems, n(n-1) translators would be required. As vendors modify their internal software and data bases, the result can be a real maintenance nightmare.

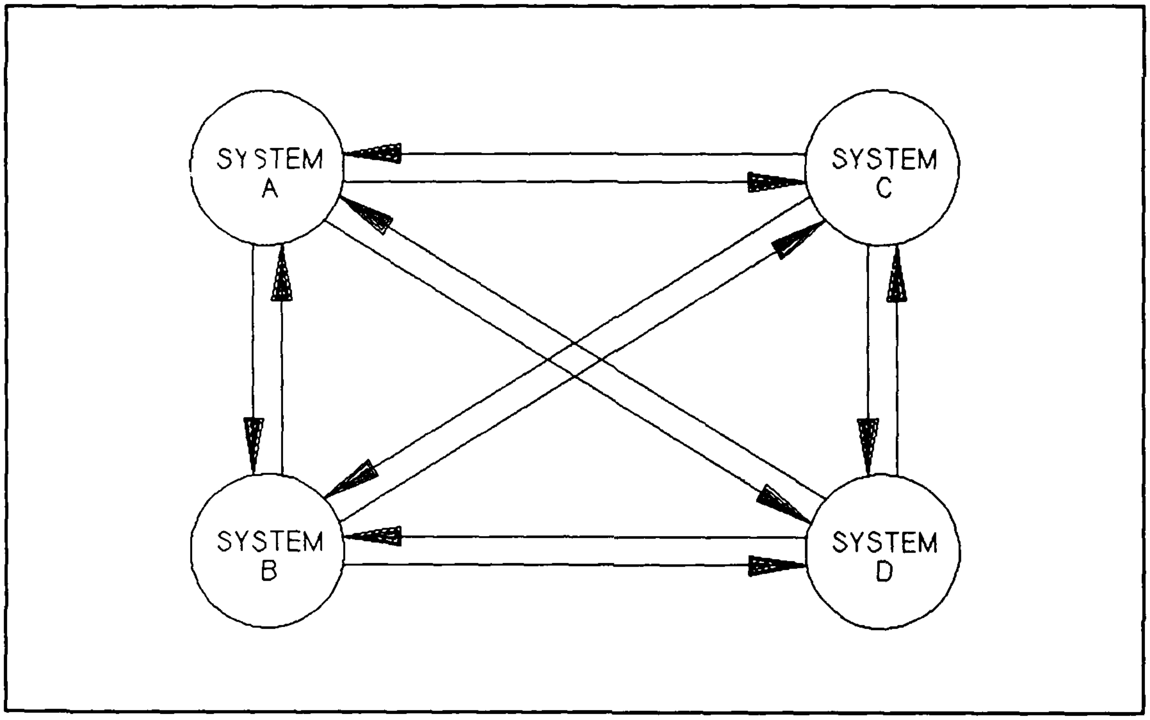

Figure 1. Direct Translators

A neutral format file is a nonproprietary format available for public use, generally as a national or international standard. It is a common medium for sharing data electronically between different software systems. It is an appealing concept because only two pieces of translation software need to be written for a software system, no matter how many software systems you wish to exchange data with using the neutral format file. These pieces of software are the *pre-processor*, which reads the data from a software system into the neutral format file, and the post-processor, which reads the neutral format file into the software

system. As Figure 2 illustrates, four systems wishing to exchange data require only eight pieces of software to be written, (two translators to support each system); for five systems the number of translators required goes up to ten. For n systems wishing to exchange data electronically, only 2n translators need to be written. Since only two translators are required for each system, the software vendor usually develops the translation software, often marketing it as an option that may be purchased with the system. Vendor supplied and supported translators shield the user from updating the translation software when a new version of the neutral file format is released.

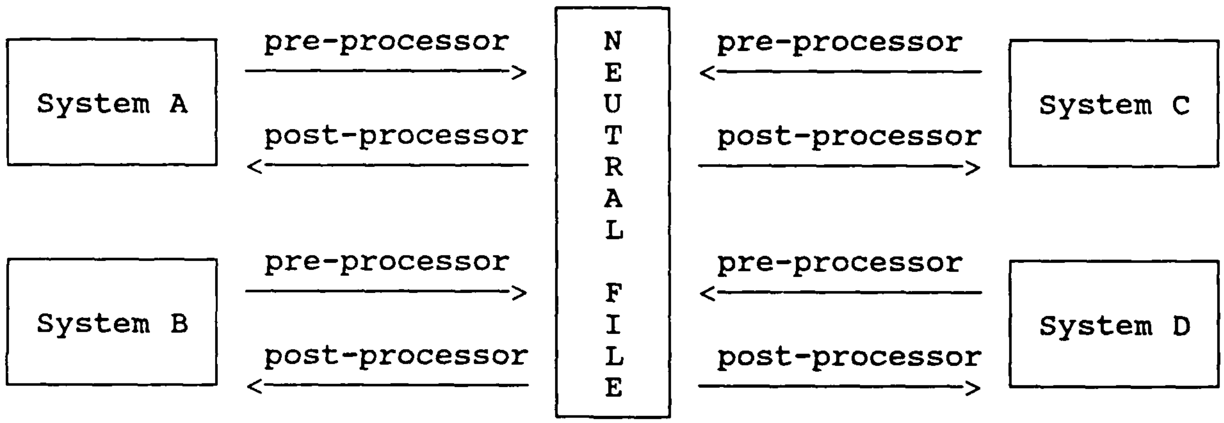

Figure 2. Neutral File Translators

In any data exchange process, there are a multitude of problems which may occur in the translation process. For example, in IGES where neutral file translators are used, the sending software system might not have output their entire CAD model into the IGES file. All the functionality on one software system may not transfer to the receiving software system, i.e. the graphics may transfer, but the meaning may not. The neutral file specification may be ambiguous in places, and the software vendors may have interpreted the specification differently or the entity may simply have been transferred incorrectly. For example, in transferring text, a particular font may not be supported by IGES and the translator may have been developed to interpret the letters as line segments. Although, the translation will result in a perfect visual match, the fact that the line segments represent text (the meaning or functionality of the line segments) will be lost.

If an error occurs in the exchange, the software system that caused the error must be identified before it can be fixed. First, the user must determine that the entity was sent. A translator may

not output all the software system's native entities to the IGES file, either because there is no appropriate IGES entity to translate the systems native entity into or because the vendor hasn't written anything yet to support that native entity. Then the user must determine if the receiving system can read that type of entity. If both of those steps were satisfactory, then the user must determine if the error was in reading or writing the file. To check if the file's structure was written correctly, an IGES file syntax checker may be used. A syntax checker confirms that the file's structure was put together correctly. If the IGES file is run through a syntax checker, and no error messages are produced for the entity, it would indicate that the error is probably on the receiving software systems side.

Often there will be a choice of different standards to use for an exchange. Different standards usually have slightly different design intents and are thus better in some applications than in others. For example, one could transfer a picture of an engine for a technical repair manual using IGES, but since IGES was intended for representing engineering drawings, the visual presentation of items such as dimensions or text fonts may not be exact. Another standard concerned with accurate pictorial representations, such as the Computer Graphics Metafile (CGM) or Raster, might be a better choice.

1.3 STANDARDS, SPECIFICATIONS AND THEIR IMPLEMENTATIONS

The first step in creating a national standard is to create a specification, which can be thought of as a draft standard. The specification documents the agreements reached by consensus of a special interest group which addresses the problem at hand, and contains a set of rules for defining data to be exchanged. For example, in the case of IGES a neutral file format is specified. This special interest group manages the development, extensions and documentation of the potential standard. The IGES/PDES organization is responsible for the activity for the IGES specification. Anyone interested in developing the standard can participate in the group, and after attending two meetings can vote on issues affecting the standard.

After achieving consensus in the standards making body, the standard is then submitted to a standards endorsement organization, such as the Institute of Electrical and Electronics Engineers (IEEE), American Society of Mechanical Engineers (ASME), or the Electronics Industry Association (EIA). These are organizations that have been sanctioned by the American National Standards Institute (ANSI) to approve standards as ANSI standards. This provides the specification a broad public review. The specification is then published and released as a standard, after a successful review and balloting process.

At this point the standard is not usable by the general public as it is simply a document and not yet implemented. A software developer must then implement the standard into a software product before it can be used. In the case of *IGES*, the software product (called a translator) transmits only the set of entities that the software developer chose to implement. In actual practice the set of entities implemented by the vendor is a subset of the entities described in the standard. The standard does specify controls, formal tests or certifications to check that the implementation was performed correctly. The standard also may lag behind the current state of the art in industry.

1.4 TESTING

1.4.1 *LOOP TESTING*

Loop testing and end-to-end testing are the two most common types of testing that are performed. Loop testing consists of sending a file from the CAD system into the IGES format and then reading that file back into the original CAD system. This test checks whether the translator can read in data that it wrote. It is a basic start for testing. The problem with this approach is that the same person or group usually writes the IGES pre-processor and the IGES post-processor, and people tend to be consistent when they misread the specification. So loop testing tends to check whether the vendor was *consistent in his implementation of an entity, not* whether it was implemented correctly.

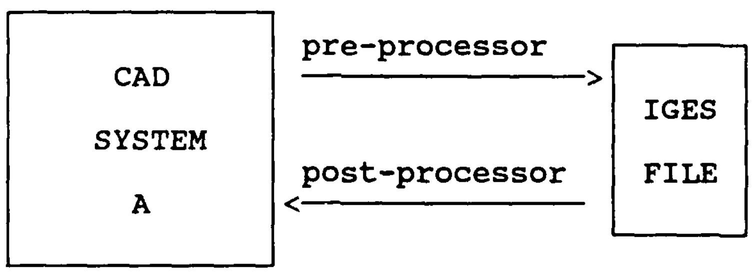

Figure 3. Loop Testing

1.4.2 END-TO-END TESTING

End-to-End testing checks the transfer of data from one CAD system to a different system. If the data does not appear as expected on the *receiving* CAD system, the IGES file must

be examined (see IGES File Analysis, section 1.4.3) to see if the data was put there correctly by the sending CAD system. If so, then the errors were introduced by the second translator (post-processor). This is often a more useful test, as it tests the conditions that a user encounters in an actual data exchange. The CALS Test Network was established to perform end-to-end testing among government agencies and between government and industry.

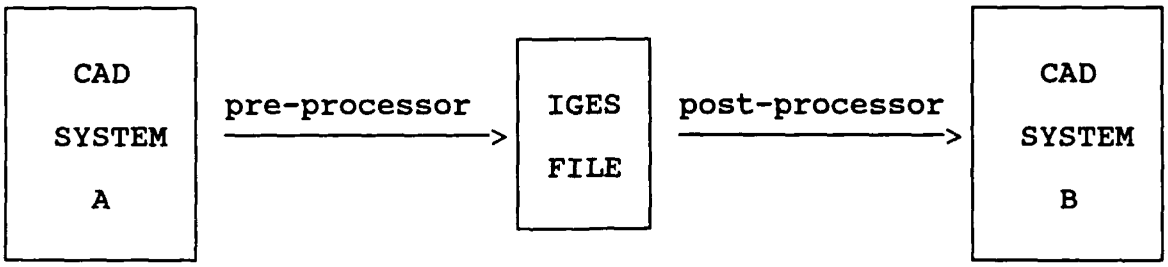

Figure 4. End-to-End Testing

1.4.3 IGES FILE ANALYSIS

There are many IGES products on the market that aid in the process of testing. IGES file analyzers read an IGES file and check its syntax, returning an analysis of the syntax errors (whether the file format is correct) and warnings about questionable conditions. Most IGES translators also check the file syntax, but not to the extent of an analyzer, and they will not return all the diagnostic messages about the file that an analyzer will. One point to keep in mind when using analyzers is that they are software systems also, so they may contain errors.

1.4.4 VERIFICATION TESTING

Verification testing is performed on a single vendor's pre and/or post translator. It tests the completeness and correctness of the entities that a vendor claims to have implemented from the IGES Specification in the pre and post processor. The results from the verification test should provide information for users to make their own evaluation of the value of a particular IGES translator for their particular application.

The IGES Verification Methodology Committee is enhancing the procedures for a National IGES verification program. It

is working with the National Institute of Standards and Technology (NIST) and the Society of Automotive Engineers (SAE) to set up an initial test of the concept. The SAE is functioning as the independent, impartial party needed to conduct and direct a testing effort, and NIST is providing the initial funding needed to start the testing effort. It is intended to be self funded through fees charged to the vendors after the initial testing of the methodology is finished. After the initial test, any changes needed to the procedures will be made and the formal verification testing of IGES translators will commence.

1.4.5 APPLICATION VALIDATION TESTING

Application Validation testing attempts to confirm that information can be completely and reliably exchanged within a given application area (e.g., engineering drawings, 3-D piping, etc.). It is concerned with determining whether the product data, all the information needed to specify and support the product over its lifetime, is transferred from one CAD system to another. IGES translators may imbed product information differently, and some data may become lost when the IGES file is read by the post-processor. Application validation testing checks a translators capability to support the specific application protocols. Application protocols are concerned with both the manner in which an IGES file is constructed and with the intended meaning of the entities used. For a particular application protocol only certain entities are permitted to be used and these entities will have a definite meaning within that particular application protocol. The same entities, when used in a different application protocol, may be assigned a different meaning (or interpretation).

Application validation testing checks whether a translator is capable of translating all entities required for a specific application. Whereas, verification testing only checks whether a translator is capable of accurately translating entities that the developer claims to translate without regard to whether the translator can satisfy a given application.

1.4.6 CALS TEST NETWORK

The CALS Test Network (CTN) was established to test the exchange of digital product definition data using MIL-D-1840A, and to recommend changes to that document. The testing will start with the following standards: MIL-D-28000 Representation for the Communication of Product Data, IGES Application Subsets; MIL-M-28001 Markup Requirements and Generic Style

Specification for Electronic Printed Output and Exchange of Text (SGML); MIL-R-28002 Raster Graphics Representation in Binary Format, Requirements for; and MIL-D-28003 Digital Representation for Communication of Illustration Data: CGM Application Profile. The testing is directed by the Air Force Logistics Command and performed by Lawrence Livermore National Laboratories, the military services and volunteer companies.

The CTN will test the current CALS data interchange standards, but is not trying to specifically test whether the software systems used (e.g., translators) conform to the CALS standards. The purpose of the network is to "evaluate the effectiveness of CALS standards for data interchange" and "demonstrate the effectiveness and benefits of employing digital data exchange rather than paper copy". The tests used will be end-to-end tests, under actual conditions and structured tests. The results that have been reviewed and approved by the CTN will be available on the CALS bulletin board for public view.

1.5 FLAVORING

In an ideal situation translators would be capable of transmitting data between two different software systems via a neutral file without any concern as to which sending/receiving system was involved in the transfer. In actual practice however, as in the case of IGES, all translators do not support the entire neutral file standard and the specification permits more than one way to represent an entity. Since the IGES specification is ambiguous, each vendor's interpretation and implementation of the standard may differ. As a result, knowledge of the sending and receiving system as well as the vendor's interpretation of the specification is useful to ensure complete and accurate data transfer. Flavoring is the term used to describe modifying an IGES data file and producing a new IGES file tailored for the capabilities of a specific CAD/CAM systems' IGES processor. There is often more than one way to represent an entity in an IGES file. For example, a surface could be a Parametric Spline Surface, B-Spline Surface, Ruled Surface, Tabulated Cylinder, or Surface of Revolution in an IGES file. The representation usually depends on what the entity was in the native database. All IGES translators do not support all of the entities in the IGES specification. IGES files are said to come in many different "flavors", because of the many different entities and forms numbers available for representing an object in the IGES format.

Since the translators do not support all of the entities in the IGES specification, either in their translators or in their internal database an IGES file is created that has a specific CAD systems' flavor. For example, a sending CAD system's IGES pre-processor may only be capable of writing a particular internal

entity to only one IGES entity type in the IGES file. Another CAD system's IGES post-processor may not be able to read that specific entity type, sometimes even if it's available within the CAD system. As a result, without flavoring, the two systems will be capable of exchanging only the IGES entities common to both CAD systems, as illustrated in Figure 5.

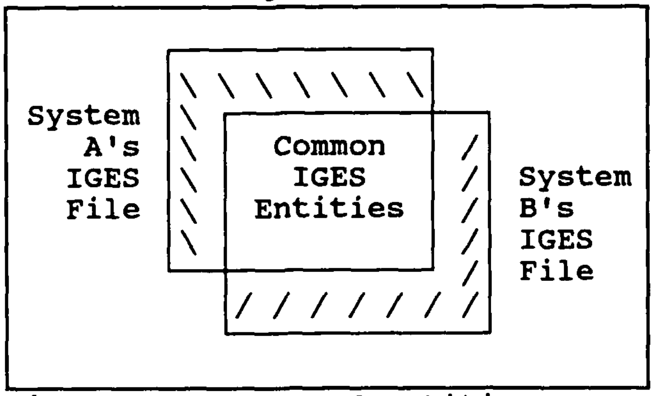

Figure 5 Overlap of Entities

Even if both CAD systems support an entity there still can be problems. For example, many CAD systems use layering, where entities can be grouped together and stored with each grouping of entities called a layer. Each layer may be displayed individually or as a composite overlay to display or hide parts of the model. Two CAD systems may support layering differently. System A may allow 255 layers, (layers 1 to 255). System B may allow 1029 layers, (layers 0 to 1028). If system B sent system A an IGES file with entities on every layer, system A's IGES post-processor would have to move the entities that were on layers 0, and layers 256 through 1028 to new layers understandable to system A. The scheme the translator uses might be unsuitable for a given application. For example, the translator may put all of the entities from layer 0 and layers 256 through 1028 on system B onto the same single layer on system A.

One way to cope with this problem is to use flavoring software to convert IGES entities from one entity type to another, or otherwise manipulate the IGES file, as shown in Figure 6. Many IGES pre-processors have some flavoring capabilities built into them. They offer a choice of the IGES entity type that a specific internal CAD entity will be written to in the IGES file. This requires some knowledge by the sending system's user of what the receiving CAD system can post process, before he can decide upon the entity types that should be in the IGES file. One point about flavoring software that should be kept in mind is that it does modify the IGES file. If an error in translation is found in a file that has been altered using a flavorizer, then the flavorizer must also be checked as a possible source of the error.

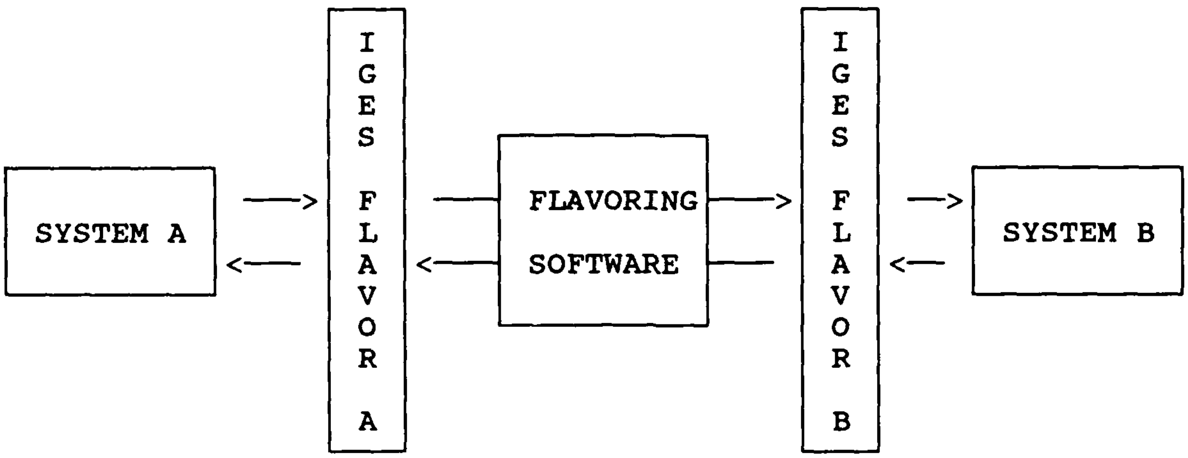

Figure 6. Flavoring Software

The Department of Energy has developed the DOEDEF (Department of Energy Data Exchange Format) software package which will shorten the time required to develop flavoring software. The DOEDEF software tool facilitates developing user-written IGES flavor translators by performing file maintenance tasks as the database containing IGES entities is modified. When a new IGES file is output, the "housekeeping" details of the IGES file, such as pointers and sequence numbers, are automatically updated. A tool like DOEDEF is helpful when writing a flavor translator, but the programs to change IGES entities from one entity type to another entity type must still be written.

1.6 INITIAL GRAPHICS EXCHANGE SPECIFICATION (IGES)

The Initial Graphics Exchange Specification (IGES) was initiated in 1979 by a small group composed of representatives from Boeing, General Electric and the National Institute of Standards and Technology (NIST, formerly the National Bureau of Standards). The first version of IGES was published in 1980 and approved by the American National Standards Institute (ANSI) in 1981 as a national standard. Version 2.0 of IGES was published in 1983 (but was not issued as a national standard). NIST published the IGES version 3.0 specification in April, 1986. The IGES 3.0 specification was approved by ANSI as ANSI Y14.26M and is the current national standard. The standard describes a file format to allow the communication of "the data required to describe and communicate the essential engineering characteristics of physical objects as manufactured products." It is composed of units of information

called entities, both geometric and non geometric, that are linked together in a sequential file to describe a CAD model. A summary of the IGES entities in the 3.0 document are:

- surfaces: parametric, b-spline, offset, trimmed, ruled, surface of revolution, tabulated cylinder, etc.

- curves: lines, circles, conics, b-splines, etc.

- points: normal point, connect point

- annotation: angular, diameter, ordinate point and radius dimensions, symbols, notes and labels, etc.

- structure: groups

- external file references for libraries of components or symbols

- finite element modeling data

- electronic printed wiring board data

- text fonts

IGES 4.0 was published in April, 1988 and has been submitted to the American National Standards Institute (ANSI) for approval as a national standard. The major additions to version 4.0 are Constructive Solid Geometry (CSG) solids, parameters for electrical products and the concept of "gray" pages. "Gray" pages are the section of the document that holds new untested entities. These entities are removed from the gray pages and put into the main portion of the specification when three production translators support that entity. IGES 5.0 is scheduled for publication in July 1990, and will contain boundary representation (BREP) solids.

The IGES organization has published a Recommended Practices Guide to aid the implementers and users of IGES. It suggests interpretations of the specification for the complex, or ambiguous sections and fills in omissions in the specification. Many of the recommendations proposed in the guide that clarify an omission or ambiguity in the specification are later incorporated in the next version of IGES. An example of this is the delimiter for separating fields. In version 3.0 there were no limits on what the character for a delimiter could be. A recommended practice was issued disallowing the use of control characters, space, numbers, and a few other common symbols usually used as data in the file, for a delimiter. This restriction was then incorporated into IGES 4.0. The current version of the Recommended Practices Document is 4.0, released in March 1988.

1.7 APPLICATION SUBSETS AND PROTOCOLS

The IGES specification is a large, (170 entities in version 4.0), and complex specification with various choices on the type of IGES entity that a CAD model entity could be translated into. As a result, software vendors seldom support every entity in the specification, but support a subset of the specification that best matches the features of their CAD system. Invariably, there is a mismatch between the set of entities utilized by one CAD systems pre-processor and another CAD systems post-processor. Many times the intersection of the supported entities is adequate for data transfer, but not in all cases. So, the entities needed may not transfer completely. As a result, the statement "I support IGES version 4.0" by a vendor, should be interpreted as the particular vendor supports an assortment of version 4.0 entities, but most likely not all of the entities.

Application Subsets are the initial approach to overcoming the incompatibility of CAD systems as a result of mismatching entity support. They are intended to divide the IGES manual into brief, related portions. This informs the user about the type of entities to expect in an IGES file that conforms to an application subset. An application subset is developed by identifying an application area, for example Technical Illustrations. The IGES entities used by that application are identified as a subset. A file conforming to the subset may use only the entities specified in that subset for product definition. As stated by MIL-D-28000, other entities may be present in the file if: they are valid IGES entities; not necessary for the product data description; or are just for regenerating the same development environment on the CAD system that originally developed the file. Following these rules the receiving system can reject the "volunteer" entities without causing a negative effect on the transfer. The concept of application subsets lets a user specify the particular type of IGES file he wants to exchange.

As defined by IEEE, a protocol is a set of conventions or rules that govern the operation of functional units to achieve communication. Application Protocols are the next logical step from application subsets, because protocols provide both a subset of entities and what those entities mean or represent within the application protocol, as shown in Figure 7 (page 18). The protocols are created by modeling the application area's information requirements using an information analysis modeling methodology. Based on the models, the application area experts decide what IGES entities would best carry the required information.

APPLICATION SUBSETS	APPLICATION PROTOCOLS
-entity lists -restrictions	-information model -format specification -set of test cases -entity meaning

Figure 7. Relationship between subsets and protocols

The IGES/PDES Application Validation Methodology Committee (AVM) is working on refining the definition of application protocols. They are working with other IGES/PDES technical committees to create the Technical Publications Application Protocol, the Engineering Drawings Application Protocol, the 3-D Piping Application Protocol and the Electrical Products Application Protocol. MIL-D-28000 reveals an interest in application protocols; Section 6.1, states "It is the intent of this specification to evolve in the direction of application protocols to ensure quality data exchanges".

An example of an application protocol would be the draft 3-D Piping IGES Application Protocol, which describes the representation and exchange of 3-D piping models for the arrangement of piping and pipe-connected equipment. A portion of the protocol discusses the representation of a pipe. Pipes are represented by composite curve entities, which contain lines, arcs and connect points. The line represents a straight part of the pipeline, a circular arc represents a curved portion of the pipeline or elbow, and the connect point represents either a start/stop on a pipe or a component connect. If these entities were transferred without using the protocol, the wire frame data would be received without information on its meaning. But if these entities were passed using the 3-D piping application protocol to an IGES post processor that supports this application protocol, then the idea that the composite curve represents a pipe can be understood by the translation software and the CAD system. The goal of application protocols is to allow more transfer of objects instead of merely a wire frame representation of lines, arcs, and points with no intelligence attached. In other words, the tendency is toward product definition rather than drawings.

1.8 PRODUCT DATA EXCHANGE SPECIFICATION (PDES)

PDES is a specification currently under development for the exchange of complete product data in a computer sensible format. Product data in its fullest sense is the data needed to design, manufacture and support a product through its life-cycle. Product Data includes product definition data (the data elements required to completely define a product) and the additional elements required for reliability and maintainability. PDES is being developed by the IGES/PDES Organization with participation from the International Standards Organization (ISO).

The International Standards Organization (ISO) approved the PDES document submitted for ISO registration in November, 1988, as a formal Draft Proposal. The document submitted to ISO contains data models which can describe only a subset of the product data required to represent a given product and is intended to permit international review and to serve as a check point for the PDES development effort. The ISO registration does not imply approval of its content, but does begin the international balloting that will produce consensus approval of the specification. The final stages of ISO standardization are the elevation of the Draft Proposal to the status of a Draft International Standard (earliest possible date January 1990) and finally to an International Standard (earliest possible date January 1991). PDES version 1.0 will be a subset of the Draft Proposal and will be known as STEP (Standard for the Exchange of Product Data) once it is approved by ISO. STEP will be the actual standard, approved by the international standards making body. While, PDES is the specification that is being developed in the U.S. and submitted for approval as STEP. The intent is for PDES and STEP to be identical.

PDES, Inc. was formed in April 1988 to accelerate the development of the PDES. The members of the non profit group are Boeing, General Dynamics, General Electric, Grumman, Lockheed, McDonnell Douglas, Northrop, DEC, FMC, IBM, Prime/Computervision, LTV, Rockwell, Martin Marietta, General Motors, Newport News Shipbuilding and Westinghouse, and NIST participates as a Government Associate. These companies provide the technical resources and personnel needed by the program with general management furnished by the South Carolina Research Authority (SCRA). Phase I of the PDES Inc. program focuses on the validation and implementation of the PDES/STEP Draft Proposal mechanical parts subset. PDES, Inc. is organized into three technical areas: modeling and integration, testing and validation, and technical products/implementation. Phase II will broaden the scope to include electronic components and assemblies.

The IGES and PDES specifications will be developed in parallel until PDES can be used in production data exchange with similar capabilities to the current IGES standard. An informal poll of the vendors in the IGES/PDES Implementers Committee during the January

1989 meeting, concluded that they will not have PDES translators with capability comparable to the current IGES translators for approximately five years. Current IGES translators are capable of transferring some product data (e.g., the SEAWOLF digital data exchange project has demonstrated the capability to transfer structural data using IGES translators). In the interim, an IGES version 6.0 is anticipated, but the scope has not yet been defined.

1.9 ELECTRONIC DATA INTERCHANGE (EDI)

The Government and Industry process large amounts of paper for business purposes. A sizable portion of this involves transactions external to the firm for business related documents. These documents include purchase orders, invoices, sales price/sales catalogs, shipping notices/manifest, contracting documents, etc. These documents may be created on computer systems, but usually cannot be sent to the intended outside organization electronically because of the different computer system format needed by the receiving organization. If the group that receives the document tracks or processes it electronically, then it must be re-entered on the computer, which in turn delays the turn around time of the transaction.

Electronic Data Interchange (EDI), ANSI ASC X12, is a standard for automatic computer to computer interchange of data used in business transactions. It provides a standard format that the business data in computer data bases can be translated into for the transmittal of the EDI formatted data to another organization. Using the EDI format the data is automatically translated into a receiving systems data base. Implementations of the EDI standard eliminate the need to re-enter business data.

The Deputy Secretary of Defense announced on May 24th, 1988 that EDI will be used as the DoD standard for electronic data interchange. The Director, Defense Logistics Standard Systems Office (DLSSO) is responsible for providing information support to DoD in using EDI and representing the DoD needs to EDI standards making bodies. The services have designated representatives to serve on a Joint Service/Agency Logistics EDI committee and program project teams, and will be responsible for implementing approved EDI standards.

EDI is not yet a CALS standard. But, work is underway to include Electronic (business) Data Interchange transactions to support CALS technical information as a future CALS standard. A proposed extension to the ANSI X12 standard will be used to define a MIL-STD-1840A compatible transaction set for enveloping CALS data within an EDI transaction.

1.10 REFERENCES

1. Verification Testing of IGES translators: Organization and Approach. Draft Version 2.0, IGES Verification Testing Methodology Committee, January, 1989.

2. Overview of IGES Testing. Version 0.7, IGES User Information Committee, October, 1988.

3. Initial Graphics Exchange Specification (IGES). Version 3.0, National Institute of Standards and Technology, NBSIR 86-3359, April 1986.

4. Initial Graphics Exchange Specification (IGES). Version 4.0, National Institute of Standards and Technology, NBSIR 88-3813, June 1988.

5. Guidelines for the Specification and Validation of IGES Application Protocols. Version 0.07, Randy Harrison, Mark Palmer, IGES/PDES Organization, January 1989.

6. MIL-D-28000, Digital Representation for Communication of Product Data: IGES Application Subsets. CALS Policy Office, November, 1988.

7. Software Engineering Standards: Glossary of Software Engineering Terminology. ANSI/IEEE Std 729-1983, IEEE, Inc. 1984

8. CALS TEST NETWORK STRATEGIC TEST PLAN. Lawrence Livermore National Laboratory, July 1988.

9. The ABC's of Standards-Related Activities in the United States. Mureen A. Breitenberg, National Institute of Standards and Technology, May 1987.

10. EDI Plan of Action. John Mittino, Deputy Assistant secretary (Logistics), December 1988.

11. An Introduction of Electronic Data Interchange. ANSI ASC-X12, July 1987.

12. 3-D Piping Application Protocol. NIDDESC, January, 1989.

2.0 CALS STANDARDS OVERVIEW

Standards and specifications are being developed by CALS to provide the common interfaces needed to improve Industry and DoD productivity and quality in both acquisition and logistic support in the interchange and efficient use of digital data. CALS phase I focuses on standards for digital interchange of technical information among dissimilar computer systems. Initial CALS standards are intended to enable the digital delivery of engineering drawings and technical manuals including illustrations. CALS phase II focuses on the standards needed to access and manage data within a distributed data base. MIL-HDBK-59, Computer-Aided Acquisition and Logistic Support (CALS) Program Implementation Guide, is DoD's guidance document for the implementation of CALS. Each service is responsible for issuing implementation guidance of their own. MIL-HDBK-59 provides an overview of CALS and provides guidance on the use and delivery of digital data. Under that standard lies MIL-STD-1840A, Automated Interchange of Technical Information, which provides technical information on the specifications used in CALS, the packaging of the digital form, and basic concepts.

Current CALS data exchange standards/specifications are:

1. MIL-STD-1840A, "Automated Interchange of Technical Information"

2. MIL-D-28000, "Digital Representation for Communication of Product Data: IGES Application Subsets"

3. MIL-M-28001, "Markup Requirements and Generic Style Specification for Electronic Printed Output and Exchange of Text"

4. MIL-R-28002, "Requirements for Raster Graphics Representation in Binary Format"

5. MIL-D-28003, "Digital Representation for Communication of Illustration Data: CGM Application Profile"

Future standards will address data interchange in terms of both technical data elements and the life cycle functional applications that use the technical data. Future CALS data exchange standards are likely to include:

6. MIL-STD-1388-2B, Logistic Support Analysis Record

7. PDES, Product Data Exchange Specification

8. EDIF, Electronic Data Interchange Format

9. VHDL, VHSIC Hardware Description Language

10. ODA, Office Document Architecture

2.1 AUTOMATED INTERCHANGE OF TECHNICAL INFORMATION (MIL-STD-1840A)

2.1.1 PURPOSE

MIL-STD-1840A is the "parent" standard for a family of military specifications known as the CALS standards. It describes the digital data files for a complete deliverable with respect to CALS standards MIL-D-28000 (IGES, for computer aided design vector graphics), MIL-M-28001 (SGML, for text), MIL-R-28002 (for raster scanned images), and MIL-D-28003 (CGM, for technical illustration vector graphics). Its purpose is to standardize the digital interface between systems exchanging digital forms of technical information necessary for the logistic support of weapon systems. It governs the interchange of digital technical information and specifies the media, procedures, labels, identifying data, and standards for transfer of various types of technical information.

The format, information structures, and transfer procedures established in MIL-STD-1840A are applicable in all cases where information is prepared, transmitted, and received in the form of ASCII text files, product definition data files, raster image files, or graphics files. MIL-STD-1840A does not restrict any current applications. In other words, it is intended as a single source for describing digital data files needed to exchange data between organizations/computers.

2.1.2 TYPICAL APPLICATIONS

MIL-STD-1840A addresses technical publications (such as training manuals, technical manuals with associated figures, etc.), product definition data (such as engineering drawings, etc.), and the evolving product data concept which provides for transfer and archival storage of technical data.

2.1.3 SCOPE

MIL-STD-1840A covers two types of documents delivered in digital form: Technical Publications and Product Data.

2.1.3.1 TECHNICAL PUBLICATIONS

The text and illustrations of technical publications shall be organized into "file sets" which are collections of files containing the complete publication. Figure 8 (page 26) illustrates file sets on a MIL-STD-1840A tape. The data shall be "encoded" in the format described below as specified by the contract requiring the data. The data file header records

shall accompany the file set. A declaration file which uniquely identifies the document being delivered shall be included in the file set. The file sets which comprise a publication shall be in one of the following forms:

a. A raster page image file set shall consist of a declaration file and the actual (raster page image) files. Each file shall be accompanied by data file header records.

b. A page description language (PDL) file set shall consist of a declaration file and the PDL files as specified by the contract. Each file shall be accompanied by data file header records.

c. An SGML (Standard Generalized Markup Language) "Conforming" file set shall consist of the following: a declaration file; the SGML-coded text files with accompanying data file header records; and the illustration data files in IGES (Initial Graphics Exchange Specification, in accordance with MIL-D-28000), raster (in accordance with MIL-R-28002), and/or CGM (Computer Graphics Metafile, in accordance with MIL-D-28003) format with accompanying data file header records. The term "conforming" means that the SGML-coded text file and the output specification conform to MIL-M-28001.

d. An SGML "Non-conforming" file set shall consist of the following: a declaration file; the SGML-coded text files with accompanying data file header records; the illustration data files in IGES, raster, and/or CGM format with accompanying data file header records; the Document Type Definition (DTD) data file with accompanying data file header records; and the non-conforming output specification data file with accompanying data file header records. The term "non-conforming in this context means that the publication being delivered was developed in accordance with military specifications other than those cited in MIL-M-28001. MIL-M-28001 provides guidelines for the development of a DTD and Output Specification appropriate for such a publication.

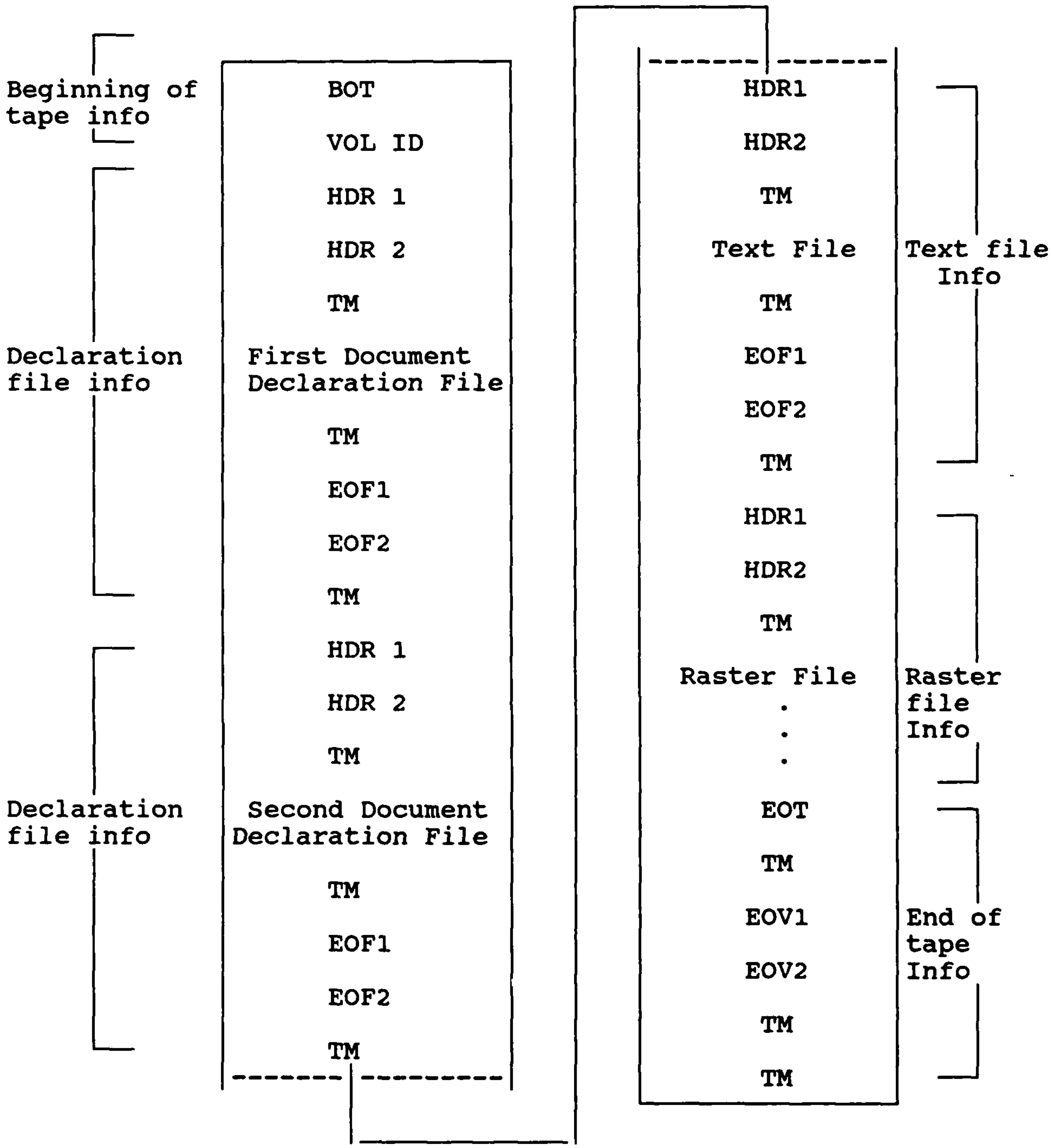

Figure 8. MIL-STD-1840A Tape Example

The technical publications listed above must be in the following format:

The declaration file shall uniquely identify the technical publication, and its format shall be 7-bit ASCII. The text source file shall consist of SGML-coded text files in accordance with MIL-M-28001 in ASCII format. The document type definition file format shall define the structure and content of the SGML-coded text file in accordance with MIL-M-28001. The output specification file shall define the style and format of the SGML-coded text file in accordance with MIL-M-28001. An illustration data file shall be in IGES, raster, or CGM format. Each illustration in the technical publication shall be supported by an illustration data file, except for repeated instances of the same illustration. Each illustration data file shall be accompanied by identifying header records.

2.1.3.2 PRODUCT DATA

MIL-STD-1840A defines product data as being all those data elements necessary to define the geometry, function, and behavior of a "part" over its entire lifespan as well as additional logistics elements for reliability and maintainability. MIL-STD-1840A currently requires product data be in IGES or raster format as specified by contract (obviously this will limit the product data which can be transferred until PDES becomes a part of the standard). The files of a Product Data document shall consist of the following:

A declaration file in 7 bit ASCII format to uniquely identify the document; engineering drawing data files in IGES or raster accompanied by identifying header records; electrical/electronic application data files (in accordance with MIL-D-28000) accompanied by identifying header records; or numerical control manufacturing data files (in accordance with MIL-D-28000) accompanied by identifying header records.

2.1.4 FILE STRUCTURE FOR TRANSFER

A document to be interchanged shall consist of a declaration file and at least one data file. The declaration file shall precede the document's data files. If several documents are to be interchanged, all declaration files shall be collected at the beginning and the document file groups shall follow the declaration files consecutively.

A declaration file provides information about identifiers, source, destination, classification, etc. of the document. The declaration file also tells how many files are in the file sets which make up the complete document.

A data file type is one of the following: textual file, DTD file, output specification file, IGES file, raster file, CGM file, special word file, PDL file, or Gray Scale data file.

Identifying header records shall accompany a data file. A record identifier shall be the first characters in a record; a colon and a space character shall terminate the record identifier string. For example, a textual data file header record shall contain the following information: source system document identifier, destination system document identifier, text file identifier, figure identifier, source graphics filename, data file security label, and notes.

2.1.5 TRANSFER MEDIA

Either of the following transfer media can be used:

2.1.5.1 Magnetic Tape - Tape format shall be written in accordance with FIPS PUB 79. 1600 and 6250 CPI (only on 9-track tapes) are acceptable in accordance with FIPS PUBS 25, 50, and 79. Multi-volume tapes are also acceptable.

2.1.5.2 Optical Disk - The format of optical disk data shall be specified by the contract.

2.1.6 PROBLEMS AND LIMITATIONS WITH CURRENT SPECIFICATIONS

Future revisions on MIL-STD-1840A will address product data files in "IPC" (Integrated Printed Circuits), "VHDL" (VHSIC Hardware Description Language), "EDIF" (Electronic Data Interchange Format), and "PDES" (Product Data Exchange Standard) format.

MIL-STD-1840A does not yet exploit emerging computer-based technologies such as solid modeling for system design, the interactive retrieval and use of technical information, or expert systems. It is envisioned that as these applications become more mature, MIL-STD-1840A will be extended to apply.

2.1.7 EXTENT AND NATURE OF USER AND VENDOR SUPPORT

The extent of the use of MIL-STD-1840A today depends upon the use of the standards of interchange which MIL-STD-1840A specifies. The CALS Test Network (CTN) was established to perform end-to-end testing of the exchange of digital product definition data using MIL-STD-1840A. "CALS-compliant" systems must have the capability of reading and generating tapes conforming to MIL-STD-1840A.

2.1.8 REFERENCE AND IMPLEMENTATION DOCUMENTS

MIL-STD-1840A references the current suite of CALS standards. In addition, a "CALS Program Implementation Guide" (MIL-HDBK-59) has been developed to provide information and guidance to personnel responsible for the acquisition and use of weapon system technical data.

2.2 DIGITAL REPRESENTATION FOR COMMUNICATION OF PRODUCTION DATA: IGES APPLICATION SUBSETS (MIL-D-28000)

2.2.1 PURPOSE

MIL-D-28000 is a DoD standard for the digital representation of product definition data using the Initial Graphics Exchange Specification (IGES) application subsets. IGES is a neutral format for digital interchange of product definition data between dissimilar computer aided design systems. The current standard has four defined subsets:

Class I: Technical Illustrations
Class II: Engineering Drawings
Class III: Electrical/Electronic Applications
Class IV: Numerical Control Manufacturing

The subsets are composed of entities from ANSI Y14.26M, the Digital Representation for Communication of Product Definition Data, (equivalent to IGES Version 3.0), with a few entities from IGES version 4.0, such as the unbounded plane (108 form 0). A MIL-D-28000 file must use one of the four approved subsets, indicating the specific subset used in the beginning of the file (IGES start section).

2.2.2 SCOPE

MIL-D-28000 specifies four defined subsets of the IGES standard (technical illustrations, engineering drawings, electrical/electronics applications, and numerical control manufacturing) as opposed to the entire IGES standard. The reason for this is the IGES specification is large and complex, with different options that may be used to represent the same Computer Aided Design (CAD) model entity. As a result, software vendors seldom support every entity in the specification, but support a subset of the specification that best matches the features of their CAD system. Invariably, there is a mismatch between the set of entities utilized by one CAD systems pre-processor and another CAD systems post-processor. There is no guarantee that the intersection of the supported entities is adequate for the required data transfer.

MIL-D-28000 specifies only the entities needed for a specific application. In this way the recipient of a MIL-D-28000 data file may specify the class of data he needs without becoming an expert on the IGES manual or the entities supported by various vendor translators. The only other entities allowed in the file are "volunteer" entities. As stated by MIL-D-28000, "volunteer" entities must be:

a. valid Y14.26M entities,
b. not necessary for the product data representation, and
c. meant only for restoring the environment on the CAD system that originally developed the file for transmittal.

These requirements will ensure that the CAD system that receives the file will not lose any of the product information if it does not transfer the "volunteer" entities.

2.2.3 STATUS AND PLANNED EXTENSIONS

MIL-D-28000 is based upon an underlying American National Standards Institute standard (ANSI Y14.26M, IGES version 3.0). As such, there is cooperation between the CALS office and the voluntary IGES/PDES group through the auspices of the National Institute of Standards and Technology (NIST). NIST coordinates the work towards resolution of technical comments beyond the expertise of the CALS office and works towards any viable requested changes or extensions to the underlying IGES standard. The latest release of the IGES specification is version 4.0, submitted to ANSI for ballot as a national standard, but not yet approved. A version 5.0 is currently being developed by the voluntary IGES/PDES organization.

The latest subset being developed for MIL-D-28000 is the 3D piping subset. It is being created by members of the Navy Industry Digital Data Exchange Standards Committee (NIDDESC) and the IGES/PDES Organization. The subset will be included in a future release of MIL-D-28000.

2.2.4 PROBLEMS

A possible concern with the implementation of MIL-D-28000 is the method by which the senders of a MIL-D-28000 file will produce the file. The preferred method would be for the CAD system's IGES translator to produce the MIL-D-28000 file. But, what may happen is that the CAD system may produce the IGES file and then the file may be run through a commercial flavorizer to produce a MIL-D-28000 compliant file. This method must be performed very carefully to prevent any loss of the file's underlying structure.

Even if the application subset transfers perfectly, that doesn't ensure that all of the information in the original CAD model will be translated. For example, a CAD system may recognize objects such as pipes and valves in its internal data base, but since IGES has no standard way to represent objects such as pipes and valves, these objects may be

transferred as a grouping of points, lines and curves which represent the object. The concept that a group of entities represent an object is not necessarily conveyed by the subset to the receiving CAD system. MIL-D-28000 displays an awareness of that problem by specifying that "It is the intent of this specification to evolve in the direction of application protocols to ensure quality data exchanges". The application protocol work is being developed within the IGES/PDES Organization to transfer objects instead of merely a wire frame representation of lines, arcs, and points with no intelligence attached.

2.2.5 EXTENT AND NATURE OF USER AND VENDOR SUPPORT

The IGES specification has much support from the CAD system vendors. Most CAD systems have some type of IGES translator, and even some of the non-CAD systems, such as Interleaf (an electronic publications system), support the IGES specification. The support for MIL-D-28000 (i.e., the subsets) is not as widespread as the support for the full IGES standard. The greatest stated support of the subsets comes from the commercial flavoring systems. This doesn't mean that the native CAD systems can't support MIL-D-28000. They can design their models so that the IGES entities output by the CAD system's IGES translator belong to the MIL-D-28000 subset, and manually put in the required information in the IGES start section.

2.2.6 STRUCTURE OF THE STANDARDS DEVELOPMENT ORGANIZATION(S)

The CALS standards are being developed jointly by DoD, the military, federal agencies and private industry, under the direction of the Department of Defense. Comments are solicited through comment/suggestion forms at the back of each of the standards. These are sent into the CALS Policy Office. The comments that are accepted are incorporated into an amendment to the standard, and are published in December/January. Comments on the standards can be sent to the Directory, CALS Policy Office, OASD(P&L)WSIG Pentagon, Room 2B322, Washington, DC 20301 using the form at the end of MIL-D-28000 or a letter.

The IGES/PDES Organization is developing the base standard, the Initial Graphics Exchange Specification (IGES), under the direction of the Project Manager, Dennette Harrod of Computer Vision. Changes to the Specification are submitted as a Request For Change (RFC) which are balloted by mail to all the members of the IGES/PDES organization. Any accepted changes are incorporated in the next release of the IGES specification. The specification is then sent to the American

National Standards Institute for ballot as a national standard. Comments on the specification can be addressed to: Gaylen Rinaudot, Coordinator, IGES/PDES, National Institute of Standards and Technology, Building 220, Room A150, Gaithersburg, MD 20899.

2.2.7 TESTING AND VALIDATION

The CALS Test Network (CTN) was established to perform end-to-end testing of the exchange of digital product definition data using MIL-D-1840A, and to recommend changes to that document. One of the initial standards to be tested will be MIL-D-28000, Representation for the Communication of Product Data, IGES Application Subsets. The testing is directed by the Air Force Logistics Command and performed by Lawrence Livermore National Laboratories, the military services and volunteer companies.

The CTN will test the current CALS data interchange standards, but will not try to specifically test whether the software systems used (e.g., translators) conform to the CALS standards. The purpose of the network is to "evaluate the effectiveness of CALS standards for data interchange" and "demonstrate the effectiveness and benefits of employing digital data exchange rather than paper copy". The tests used will be end-to-end tests, under actual conditions and structured tests. The results that have been reviewed and approved by the CTN will be available on the CALS bulletin board for public view.

2.2.8 REFERENCE AND IMPLEMENTATION DOCUMENTS AVAILABLE

MIL-D-28000, Digital Representation For Communication of Product Data: IGES Application Subsets

MIL-HDBK-59 Department of Defense Computer-Aided Acquisition and Logistic Support (CALS) Program Implementation Guide

MIL-STD-1840A Automated Interchange of Technical Information

(Copies of the preceding military standards may be ordered from: Department of Defense Single Stock Point, Commanding Officer, Naval Publications and Forms Center (NPFC), 5801 Tabor Avenue, Philadelphia, PA 19120.)

CALS Test Network MIL-D-28000 Class II Reference Drawing Packet Revision C, Lawrence Livermore National Laboratory, Jill Farrel, January 27, 1989. (The document contains helpful information for carrying out tests of the MIL-D-28000 class II subset.)

CALS Bulletin Board Numbers: (301) 921-9842
(301) 948-7438

The latest released IGES Specification can be ordered from the

National Technical Information Service (NTIS):

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Telephone: (703)487-4650

2.3 MARKUP REQUIREMENTS AND GENERIC STYLE SPECIFICATION FOR ELECTRONIC PRINTED OUTPUT AND EXCHANGE OF TEXT (MIL-M-28001)

2.3.1 PURPOSE

MIL-M-28001 establishes requirements for the digital interchange of technical publication text between contractors and the government. MIL-M-28001 is the DoD implementation of the international standard ISO 8879 "Standard Generalized Markup Language (SGML)". Some familiarity with SGML is needed to understand MIL-M-28001.

The SGML standard defines a method and a "language" for document representation. It provides a formal markup ("document tagging") procedure independent of system and output environments. It provides a coherent and unambiguous syntax ("language") for describing whatever a user chooses to identify within a document - the document's "structure" - regardless of the type of document or the nature of the document's text. The definition of the document structure in terms of "elements", "entities", and other components is a "Document Type Definition (DTD)". A DTD defines the structure of a specific class of documents. Paragraph 2.3.9 presents illustrative examples.

The SGML markup of a document consists of inserting tags into the unformatted text. These tags identify the text's elements (titles, paragraphs, tables, footnotes, etc.) as defined by the document's DTD. SGML markup may be done either manually or by an automated procedure. The "marked up" document should be checked against the appropriate DTD to be sure that its markup conforms to the conditions imposed by that DTD. This process is called "parsing" and is done by special computer programs called "parsers".

The Department of Defense developed two DTDs for Military Technical Manuals with respect to MIL-M-38784B (Technical Manuals: General Style and Format Requirements). These two DTDs are currently provided in appendices of MIL-M-28001. The first DTD is for technical manuals which strictly conform to MIL-M-38784B. The second DTD is for technical manuals which do not conform as strictly to MIL-M-38784B. The non-conforming DTD is necessary since often an existing manual cannot be made to conform to the DTD for MIL-M-38784 conforming manuals or because the manual was written to multiple specifications. When other applications of automating technical publication are identified, and if the MIL-M-28001 DTDs are inadequate for these applications, new DTDs will be developed and added to MIL-M-28001. However, any new DTD must use the standard tag set defined in MIL-M-28001,

and must conform (as much as possible) to the structure and intent of the existing MIL-M-28001 DTDs.

2.3.2 APPLICATIONS

The development of the two DTDs currently in MIL-M-28001 was a joint effort of the Navy, Army, Air Force, and Aerospace Industry. Each representative to this joint effort brought an existing application or study of technical manual automation. The Air Force ATOS (Automated Technical Order System) project was deemed to be the only "true" DoD SGML application. Accordingly it was used as a guideline and was modified with respect to Air Force, Navy, Army, and Aerospace Industry technical manual requirements. The ATOS project is now known as "AFTOMS" (Air Force Technical Order Management System). The AFTOMS project is now revising their original DTD to conform to MIL-M-28001.

The Navy has been investigating their current library of NAVSEA Ships' Technical Manuals (NSTMs) with respect to MIL-M-28001. By creating an SGML data base of these technical manuals, it will be possible to interchange data and print-on-demand on all publishing systems conforming to MIL-M-28001.

Currently, MIL-M-28001 is concerned with the digital interchange of paper-based manuals. However, there are efforts underway to define digital interchange of "pageless" technical publications. The Air Force Human Resource Laboratory has a pilot project which uses SGML to define the interchange of maintenance data to be maintained in a relational data base from which multiple "views" of the same data can be extracted. This data base is constructed so as to facilitate implementation of the "interactive-type" (hypertext) maintenance system.

2.3.3 PLANNED EXTENSIONS

In order to format an SGML marked-up document, "associated formatting information" must be provided. This "associated formatting information" defines formatting characteristics such as a page model, font and family characteristics, point size, indenting, etc. In addition, these formatting characteristics can be changed by certain SGML tags. For example, a "paragraph" tag may trigger a change in the line leading (spacing) or a "chapter head" tag may trigger text to be "bold" or "centered". An "MIL-M-28001 Output Specification Group" was formed to develop a standard language for the associated formatting information of

SGML-tagged files. SGML was chosen as the language of the Output Specification (OS).

For each DTD, a "Formatted Output Specification Instance" (FOSI) will be developed (paragraph 2.3.9 presents illustrative examples). A FOSI will follow rules in the Output Specification and will specify parameter values for the format requirements of the document. Accordingly a FOSI for a particular DTD will describe all default formatting characteristics necessary to compose and publish a document. Authors will have the capability to override a FOSI if a format other than the default is needed for a particular document. Since FOSIs are written with respect to the standard OS, vendors will be able to develop software that can "read" FOSIs and interface with the publishing software.

In addition to the OS and FOSI extensions, there is at present a draft amendment to MIL-M-28001 which contains the notion of a "declaration subset". These declaration subsets specify slight changes to the present DTDs. The implementation of the changes in a declaration subset results in a complete DTD for the corresponding military specification: MIL-M-21742, MIL-M-26788, MIL-M-38812, MIL-M-63004, MIL-M-63036, MIL-M-63038, MIL-M-63041, MIL-M-6675, MIL-M-83943, MIL-M-9994, WS-10759-1, WS-10759-2, or WS-1759-3. This proposal for "declaration subsets" is expected to be accepted since permitting slight modification of an existing DTD allows tighter control over the number of distinct DTDs. While DoD wishes MIL-M-28001 to be implemented in a wide variety of applications, DoD is quite concerned with the uncontrolled proliferation of DTDs.

2.3.4 PROBLEMS AND LIMITATIONS WITH CURRENT SPECIFICATION

The latest official draft of MIL-M-28001 was published 26 February 1988. Industry and government agencies sent comments to the Electronic Publishing Committee (a CALS Industry Standard working sub-group). A draft report concerning these comments was prepared but has not yet been officially issued and published. As a result the solutions proposed by the committee to problems raised in the comments have not been seen and reviewed. The issues raised by industry and government agencies involve:

- method of tagging tables
- linkage of SGML tagged-text with Raster graphics
- receiving partial "change package" documents from contractors

2.3.5 EXTENT AND NATURE OF USER AND VENDOR SUPPORT

The vendor community is aware of the evolving nature of MIL-M-28001. Some are waiting until the standard is finalized, while others are beginning to implement MIL-M-28001. A large vendor community is represented on the Electronic Publishing Committee. In a CALS environment, vendors supporting MIL-M-28001 must not "hard-code" their systems to process only a single DTD/FOSI. Most certainly there will be more SGML applications (DTDs) in the future and vendors whose systems can handle any given DTD/FOSI will have the advantages.

Currently there are many SGML software products on the market. These are:

- SGML parsers which conform to ISO 8879. Parsers check DTDs for completeness and consistency to all ISO 8879 rules. A parser then parses an "instance of the DTD": a document marked up with tags defined in the DTD. The parser reports on errors found in the parsing process. Many general purpose SGML software packages come with a "built-in"parser.

- SGML Author/Editors which "understand" the DTD as it is given. It will guide an author through the creation of a document, not requiring the author to type in the SGML tags. The keyed in text is automatically formatted and displayed on the screen. The document can be output in SGML format, or as a formatted page description file. In other words, as the author indicates the start of a new paragraph, the editor automatically supplies the appropriate SGML tag.

- Software which automatically tags an ASCII file based on format-driven triggers. Most of the "structure" type tags (for paragraphs, lists, etc.) can be automatically generated without any trouble. However, unless the software is very sophisticated, the "content" type tags (for cross references, equipment numbers, etc.) cannot be automatically generated. Content type tags are very important in data base applications.

In addition, this type of software can be used in conjunction with media converters which translate formatted "system-dependent" files (i.e., "WordPerfect") into SGML files.

2.3.6 STRUCTURE OF THE DEVELOPMENT ORGANIZATION

The MIL-M-28001 development organization consists of two subgroups of the "CALS Industry Standards Working Group". One is the MIL-M-28001 working group, the "Electronic Publishing Committee", which is responsible for reviewing industry and Government comments with respect to the standard and proposes changes when necessary.

Another subgroup, the "MIL-M-28001 Output Specification Committee", developed the Output Specification. A sub-group of this committee is responsible for developing the FOSIs for the two DTDs currently in MIL-M-28001.

2.3.7 TESTING AND VALIDATION

Much "private" testing of MIL-M-28001 took place as part of the general review of the 26 February 1988 draft. The CALS Test Network (CTN) provides information on developing test material, identifies appropriate parties to share test material with, and distributes instructions on performing tests. Test results with regard to proposed changes to MIL-M-28001 will be submitted to the Electronic Publishing Committee. The Electronic Publishing Committee enthusiastically encourages extensive testing of the MIL-M-28001 DTDs.

2.3.8 REFERENCE AND IMPLEMENTATION DOCUMENTS

The primary SGML reference document is the International Standard, ISO 8879 "Information Processing - Text and Office Systems - Standard Generalized Markup Language (SGML)". This is the authoritative source for SGML and the most general description of SGML. All SGML implementations are based on the "language" defined therein.

MIL-M-28001 describes the Navy's use of SGML with respect to Navy Technical Manuals. It contains much useful information, in addition to providing the DTDs and master list of elements.

The "<TAG>" newsletter is published by SGML Associates, Inc., and the Graphic Communications Association, 1730 N. Lynn St. Suite 604, Arlington, VA 22209. "<TAG>" is a technical journal of the SGML community.

2.3.9 ILLUSTRATIVE EXAMPLES

For illustrative purposes, this section presents a simplified example of a DTD, an SGML "marked up" document, and a FOSI. In the examples, it is assumed that a "technical manual" document type is required to have a title and must contain at least one chapter and each chapter must have a title and contain at least one paragraph. These requirements can be stated as a simple DTD in SGML notation as:

```
<!DOCTYPE TECHMANL [
     <!ELEMENT techmanl  - - (title, intro, chap+)>
     <!ATTLIST techmanl  label  NMTOKEN #IMPLIED >
     <!ELEMENT title   -  o (#PCDATA) >
     <!ELEMENT intro   -  o (parag+) >
     <!ELEMENT chap    -  o (title, parag+) >
     <!ELEMENT chap  label NMTOKEN #IMPLIED >
     <!ELEMENT parag   -  o (#PCDATA) >
]>
```

This constitutes a simple DTD. The first "<!DOCTYPE" statement indicates that a DTD is about to be defined and the final "]>" notation terminates that definition.

The SGML markup of a simple technical manual in accordance with the above DTD may be represented as:

```
<techmanl label="437">
<title>SIMPLE TECHNICAL MANUAL
<intro>
<parag>This is the required first paragraph of the
introduction.
<parag>This is the optional second paragraph of the
introduction.
</intro>
<chap label="1">
<parag>
This is the required first paragraph of the
required first chapter
<parag>
This is the optional second paragraph of the
required first chapter.
<chap label="2">
<parag>
This is the required first paragraph of the
optional second chapter.
</techmanl>
```

The "label" attribute modifies the "techmanl" tag by specifying that it is number 437. The "label" attribute for the "chap" tags specifies the two chapter numbers. The "end" tags referred to above are those tags beginning with "</".

Note that the DTD did not require the "</intro>" ("intro" end tag) but it was not incorrect to include it.

In order for a publishing system to format a marked-up technical manual, a FOSI must be defined for it. The FOSI is also written in SGML notation so it will be processable by computer software. An example of a simplified FOSI is:

```
<eic lgi="techmanl"> <charlist> <font size="10pt",
weight="medium"> <eic gi="title"><charlist><font
weight="bold">
<eic gi="intro"> <charlist> <textbrk startpg="1">
<puttext="INTRODUCTION">
<eic gi="chap"> <charlist> <textbrk startpg="1">
<puttext="CHAPTER">
<eic gi="parag" context="chap"> <charlist> <indent
leftindent="10pt">
```

The FOSI looks somewhat similar to the marked-up technical manual above, without any authored text. That is because, just as the marked-up technical manual follows the rules of its DTD (is an "instance" of its DTD), this FOSI is an instance of the OS (which is written as a DTD and is published in MIL-M-28001).

Each line in the FOSI example which starts with <eic gi="..."> contains the formatting characteristics for an element of the DTD. "eic" denotes "element in context". "gi" denotes generic identifier and relates to the elements of the DTD. "context" refers to the context in which the generic identifier is defined. Thus, the last line identifies formatting characteristics for paragraphs in a chapter (as opposed to paragraphs in the introduction).

According to the FOSI, the technical manual is to be formatted with font size of 10 points and medium width. The title should be bold. The introduction is to start a new page, and the word "INTRODUCTION" be automatically generated. The chapter should start a new page, and the word "CHAPTER" should be automatically generated. Paragraphs within the chapter should have a left indent of 10 points.

2.4 RASTER GRAPHICS REPRESENTATION IN BINARY FORMAT (MIL-R-28002)

2.4.1 PURPOSE AND APPLICATIONS

The MIL-R-28002 specification establishes requirements regarding the storage and transmission format of raster graphics data and tiling conventions for document pages and large format engineering drawings as raster images. Issued in December 1988, this milspec defines raster graphics data requirements for both the tiled and untiled modes. This milspec is dependent on two other government documents: MIL-STD-1840A "Automated Interchange of Technical Information" and NISTIR 88-4017 "Standards for the Interchange of Large Format Tiled Raster Documents."

Raster graphics involves the digital processing, storage, exchange and reproduction of images. This technology makes possible the binary representation of a two-dimensional image as an array of picture elements, also known as pels. Each pel of the array contains information concerning the color and brightness of that portion of the image. The quality of the image depends directly on the density of pels within the array, also known as resolution density or pel transmission density. A high resolution density provides a high quality image, but entails the added drawback of greater and more costly storage. Data compression, in which an encoding scheme is used to represent redundant bits of information, can alleviate this storage problem to some extent. MIL-R-28002 restricts such compression to Group 4 encoding as defined in CCITT Recommendation T.6 (FIPS PUB 150) in order to conform with developing industry standards. A set of graphics attributes specifying the details necessary for processing and reproducing the image is contained in a header record at the beginning of a raster file. These attributes include the size of the original image, the scanning resolution, the image orientation (whether it be portrait or landscape), the starting position on the page, and the spacing between the pels and also between the lines containing the pels. These principles and attributes are used in reproducing the image and apply to both of the raster graphics formats. Type I format applies to untiled raster graphics while the Type II format is the Type I format enhanced with tiling.

With Type II (tiled) raster graphics, an image is subdivided into non-overlapping regions known as tiles, and each tile is treated as a separate pel array. This method is especially useful for mechanical drawings in which there are

large open areas of space. Figure 9 shows an image overlayed with a grid coordinate system to produce the smaller tile

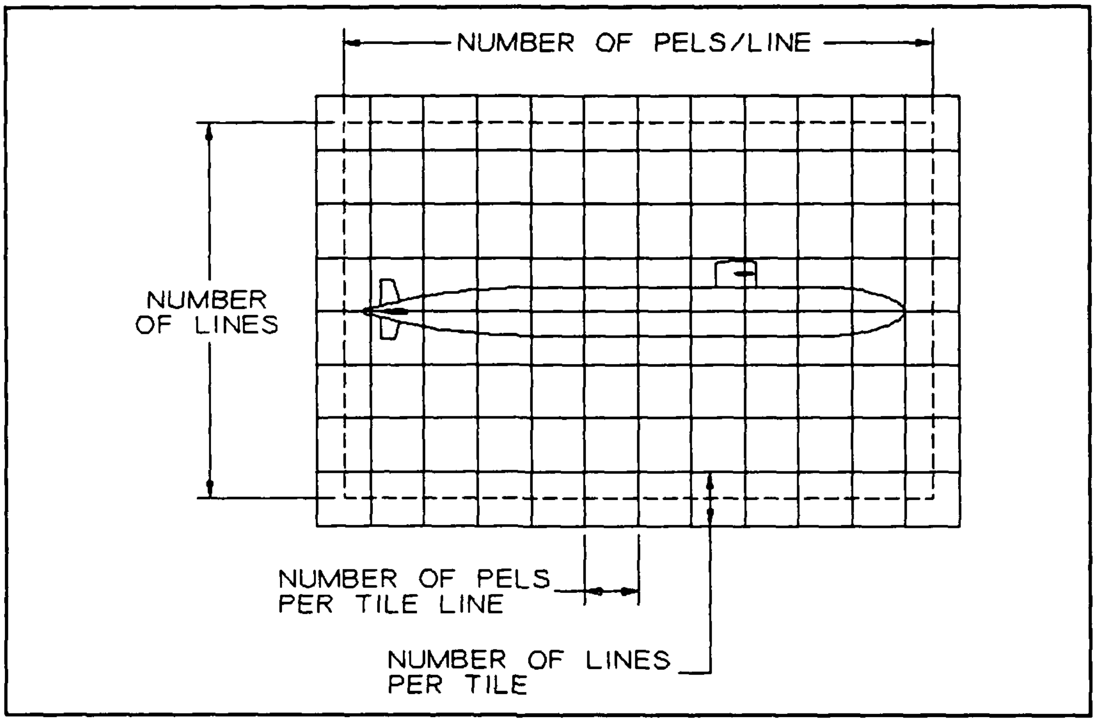

Figure 9. *Tiled Raster Graphics Example*

subdivisions. Within a single image, tiles are equal in size and their dimensions, specified in terms of pels, have limitations. Tiles can be compressed and manipulated to obtain an optimal raster graphics file. However, it is possible that compression can negatively compress or enlarge a data set, especially in busy areas of an image. Thus, compression must be employed with care. In such situations, an optimal raster graphics file can be obtained using a mixture of compressed and uncompressed tiles. MIL-R-28002 recommends that a tile index be used to allow for direct access of individual tiles. Unless a contract provides otherwise,the milspec requires Government vendors to deliver Type I (untiled) format raster graphics data.

A second group of attributes is required for Type II raster graphics. This information includes the size of each tile, the number of tiles in the array or image, the method of tile ordering, and the method of tile coding. This information is stored in the header record of an image file during the scanning procedure and is essential for reproducing an image.

2.4.2 LIMITATIONS

Although MIL-R-28002 provides specifications to unify the format of raster graphics data, there are some potential problems and limitations. One crucial issue is resolution. The specification permits resolution densities of 200, 240, 300, 400, 600 and 1200 pels per inch with a default value of 200 pels per inch. Although the milspec provides typical values for use in both document text and large size foldout drawings, it fails to specify a required value for use in either text or drawings. Most resolutions in that range result in excessive storage and processing requirements, compatibility problems, and production delays. For engineering drawings, many industry experts feel that a specified resolution of 200 pels per inch would provide adequate quality as well as cost effectiveness with respect to storage allocation, scanning equipment, and production time. The default value of 200 pels per inch is considered too low for publishing industry standards. A separate default value of 300 pels per inch for text documents may need to be specified to avoid problems with both compatibility and manuals of less than letter quality. However, at this time there is no way to determine from the header record information whether the raster file data is for a document or a drawing.

MIL-R-28002 does not specify the tiling conventions for technical manual foldouts differing in size from the standard engineering sizes A-K. This could lead to interchange problems and production delays.

With tiled raster graphics, the standard allows tiles of a graphic image to be stored as either a series of octet bit strings known as bitmap encoded data, compressed data, or a combination of the two. This procedure is optimal for data storage, but it requires alternating methods for the decompression and straight usage of data. Thus, both processing time and cost could increase.

Within the Type II tiled architecture, the "tiled context portion" attribute is permitted to have the value of "Maybe-Null-Tiles". Containing no data, null tiles are used for image compression and are particularly important to the processing of foldout drawings. However, processing null tiles can cause delays. Also, they are not necessary for text documents. Restrictions concerning the use of null tiles may be needed.

The MIL-R-28002 standard states that the typical image orientation for a page can be specified, in degrees, using the pel path and line progression attributes. This determines whether the layout will have a portrait or a landscape

orientation. If a text document is given a landscape orientation by mistake, the information will be printed incorrectly, which could be costly in terms of time and money. By forcing a portrait orientation for text pages using these or other attributes in the header record printing orientation errors could be avoided.

2.4.3 PLANNED EXTENSIONS

Some changes will probably be made to the milspec in the future, most likely in the areas of bit mapping and bit ordering in the Type II architecture. It is possible that the OSD-CALS Office will add a provision for a tiling convention in regard to technical manual foldouts.

2.4.4 DEVELOPMENT ORGANIZATION

This milspec was prepared by the OSD-CALS Office with assistance from a Government/Industry Tiling Task Group (TTG).

2.4.5 TESTING AND VALIDATION

A system for use in testing and validation is currently being developed jointly by the OSD-CALS Office and NIST (National Institute of Standards and Technology, formerly the National Bureau of Standards). This system is scheduled to be available in September 1989.

Presently, the Navy is using both tiled and untiled formats to test the conversion of documents into raster graphics files. EDMICS (Engineering Data Management Information Control System), which has been a joint effort of the Navy and Defense Logistics Agency, is in full conformance with MIL-R-28002. This management system for engineering drawings uses tiles that are 512 x 512 pels in size. Although the standards were prepared for its use in the future, tiled raster graphics format is currently being used for a repository of aperture cards at a NAVSEA facility in San Diego, CA. SPAWAR is using raster graphics with drawings for demonstration purposes. Both NAVAIR and NAVSEA are using the untiled format for technical manuals and engineering drawings. The Army and Air Force are also using the untiled format for testing their repositories of drawings.

2.4.6 IMPLEMENTATION AND REFERENCE DOCUMENTS

To assist with the implementation of MIL-R-28002, the National Institute of Standards and Technology has released

NISTIR 88-4017 "Standards for the Interchange of Large Format Tiled Raster Documents." This document describes the basic concepts of raster graphics, the architecture structure of the tiled or Type II format, and the applications of tiling. Other supporting documents of MIL-R-28002 include the following:

Specifications

DOD-D-1000	Drawings, Engineering and Associated Lists
MIL-M-9868	Requirements for Microfilming of Engineering Documents, 35 mm

Standards

FIPS PUB 150	Telecommunications: Facsimile Coding Schemes and Coding Control Functions for Group 4 Facsimile Apparatus
DOD-STD-100	Engineering Drawing Practices
MIL-STD-1840A	Automated Interchange of Technical Information

Parts 1, 2, 4, 5, and 7 of the international standard ISO 8613, which address the Office Document Architecture (ODA) and interchange format, form a significant portion of MIL-R-28002. Other standards that support MIL-R-28002 are ANSI Y14.1, ISO 8824, and ISO 8825.

2.5 DIGITAL REPRESENTATION FOR COMMUNICATION OF ILLUSTRATION DATA: CGM APPLICATION PROFILE (MIL-D-28003)

2.5.1 PURPOSE

MIL-D-28003 establishes requirements for the digital interchange of pictorial and illustration data which is delivered in the Computer Graphics Metafile (CGM) format. While IGES has its principal use within computer-aided design, CGM will be used primarily in authoring and graphic art work stations for technical manual illustrations. MIL-D-28003 is the DoD implementation of FIPS PUB 128 - Computer Graphics Metafile which adapts ANSI X3.122 as a Federal Information Processing Standard Publication (FIPS PUB). Some familiarity with CGM is needed to understand MIL-D-28003.

The purpose of the Computer Graphics Metafile (CGM) standard is to provide a flexible and standard file format for the transfer and archival of graphical information in a device independent manner. A graphical metafile (a device independent description of one or more graphic images) is a mechanism for the capture, storage, and transport of graphical information. CGM is a static picture-capture metafile. The standard only covers information necessary to recreate what is seen on the "screen". It does not contain the underlying information needed to consider the relationships of objects on the screen.

2.5.2 SCOPE - CGM Standard

CGM is described in ANSI X3.122-1986 "Computer Graphics - Metafile for the Transfer of Picture Description Information". The document contains four parts.

Part 1, the Functional Specification, identifies all standardized elements, describes their parameterizations and defines their meanings. Parts two through four, Character 2 Encoding, Binary Encoding and Clear Text Encoding describe three data encoding schemes for implementing the functionality described in Part 1.

Part 2, Character Encoding, provides an encoding using standard ASCII printable characters. The encoding is compact and is well suited to transmission via standard character oriented communications mediums. This encoding works well on character oriented network systems. It is used in Europe but rarely used in the U.S.

Part 3, Binary Encoding, describes an encoding which could be used when speed of generation and translation are very important. The encoding data formats were chosen either

for their similarity to computer data formats or were designed for speed of decoding and processing. This form of encoding is the most common form used in the U.S. (and the only encoding supported by MIL-D-28003 at this time).

Part 4, Clear Text Encoding, defines an encoding scheme which is human readable. Elements and parameters are specified in terms that are easily understandable to a person reading the metafile data. It is transmittable over character oriented communications but is slow to generate and is not very compact.

The three data encoding schemes are equivalent in the sense that any CGM in one encoding scheme may be translated to either of the other encoding schemes without losing or changing any of the picture information.

One or more pictures may be stored in a metafile and the structure of the elements is such that the pictures can be accessed sequentially or randomly. That is, a picture is an independent entity and does not rely on information in any of the other pictures in the metafile.

The CGM standard is designed primarily to represent vector graphics. It's implementation is based on the Graphical Kernel System (GKS) vector standard and uses standard vector entities such as point, line, arc, circle, polygon, etc. The standard contains a capability for bit-map like representation using a graphical primitive called cell array. The cell array is a two-dimensional array of color values which covers a rectangle or parallelogram. The standard contains a set of features to describe text fonts for use in pictures requiring type face definitions and character spacing parameters for proportional fonts.

2.5.3 SCOPE - MIL-D-28003

CGM is a government accepted standard as represented by its Federal Information Processing Standard, FIPS PUB 128. FIPS PUB 128 is a document which essentially states that ANSI X3.122-1986 is the accepted government standard. Military Specification MIL-D-28003 "Digital Representation For Communication of Illustration Data: CGM Application Profile" (CGM AP) is a DoD specific document which establishes requirements for pictorial and illustrative data which is delivered in CGM format.

The CGM AP was created to define a set of specifications appropriate to a specific application, namely the interchange of illustration data in digital format for use in technical illustrations and publications. The Application Protocol (AP)

clears up some of the ambiguities in the CGM specification that would have made it difficult to unambiguously describe a picture using a CGM. MIL-D-28003 specifies complete semantics for a CGM and describes the required behavior of CGM generators and CGM interpreters.

MIL-D-28003 defines the conforming basic metafile, conforming basic generator and the conforming basic interpreter. A conforming basic metafile is a CGM which contains only elements or parameters that are in the basic set as defined in the Application Profile. A conforming basic generator is a CGM generator which generates a conforming basic metafile, and a conforming basic interpreter is a CGM interpreter which can correctly interpret a conforming basic metafile. The AP also states some corrections for errors in the ANSI specification, provides some Quality Assurance provisions and states that the binary encoding is the only encoding supported at this time.

2.5.4 STATUS of CGM Standard / TESTING

CGM has become widely accepted in industry since it became an American National Standards Institute (ANSI) standard. It has an advantage over IGES as a vector standard in that it is an "after-the-fact" implementation and does not contain information for complex content modification, which may make it easier for a vendor to implement. CGM is an international standard, as described in the ISO document ISO 8632-1986. CGM is becoming widely available for authoring and graphic arts workstations.

There are currently no 'certified' interpreters or generators since, to date, there are no 'certified' conformance tests to determine if an interpreter or generator conforms to the standard. The ANSI CGM standard does not specify standard metafile interpreters or metafile generators. Part one of the ANSI document X3.122-1986 (annex D) provides some guidelines for implementations of interpreters but this section is not part of the standard. There are several groups, including the National Institute of Standards and Technology (NIST), which are working on developing conformance tests for CGM interpreters and generators.

2.5.5 DEVELOPMENT ORGANIZATION / EXTENSIONS

There are three major ways in which the ANSI standard can be modified. It is an ANSI practice that every five years a standard goes through a re-evaluation period to determine if any changes are necessary.

A second way to modify the standard is through addendums. Addendums currently being worked on address adding segmentation and more primitives to the standard, as well as including additional drawing and text capabilities. An addendum to add three dimensional capabilities to CGM is being considered.

The third way to modify the standard is by getting the modification or addition registered with ANSI. The process of registration is a standard way of taking care of non-standard items. A registered item is not a part of the actual standard but implementers of the standard must abide by registered items. A registered item does not have to become part of a standard but they generally do.

2.5.6 CONCLUSION

MIL-D-28003 defines the use of the CGM for two dimensional vector picture descriptions or illustrations in technical manuals. CGM is becoming widely available for authoring and graphic arts workstations, whereas IGES has its principal use within computer aided design. CGM may be a good candidate for engineering drawings which do not need to be updated. Also, the CGM cell-array bit-map feature may be a good alternative to MIL-R-28002 CCITT Group 4 compression for smaller bit-map illustrations such as might be used in a frame-based presentation system. Ongoing CGM extensions address factors needed for high quality presentation graphics and are probably not needed for technical illustrations such as being used in the CALS environment. Testing and validation are still relatively new but with increasing interest in industry these functions should progress well over the next few years.

2.5.7 REFERENCES

FIPS PUB 128, "Computer Graphics Metafile"

ANSI X3.122-1986, "Computer Graphics - metafile for the storage and transfer of picture description information"

MIL-D-28003, "Digital Representation for Communication of Illustration Data: CGM Application Profile"

Computer Graphics and applications - Graphics Standards IEEE Computer Society, August 1986

Standards in the Computer Graphics Industry National Computer Graphics Association

2.6 MIL-STD-1388-1 (LSA) AND MIL-STD-1388-2 (LSAR)

2.6.1 PURPOSE

Logistic Support Analysis (LSA) is a regulatory requirement in accordance with DOD Directive 5000.39 "Acquisition and Management of Integrated Logistic Support for Systems and Equipment" and is required in all material acquisition programs. LSA is the application of engineering and logistic efforts undertaken during the acquisition process to assure effective and economical support of a system procurement.

The tasks required for performance of LSA are defined in the standard MIL-STD-1388-1A (LSA) while the standard MIL-STD-1388-2A Logistic Support Analysis Record (LSAR) defines a system of data records, computer programs, and output reports which has been developed to document LSA.

MIL-STD-1388-1 defines the LSA process, as a result of which LSA data is created. MIL-STD-1388-2 defines the requirements for the LSAR, through which much of that data is assembled, managed, and reported.

2.6.2 SCOPE

LSA is used to obtain a reliable, maintainable, transportable, and supportable material system at the least cost of ownership by integrating logistic support considerations into the system and detail design effort. MIL-STD-1388-1A implements the LSA guidelines and requirements established by DoD Directive 5000.39. The goal of MIL-STD-1388-1A is to provide a single, uniform approach for the Military Services to conduct those activities necessary to:

(1) cause supportability requirements to be an integral part of system requirements and design;

(2) define support requirements that are optimally related to the design;

(3) define the required support during the operational phase.

The purpose of MIL-STD-1388-2A is to provide a uniform, organized, yet flexible, technical database record which consolidates the engineering and logistics data necessary to identify detailed logistic support requirements of a system. The LSAR database records are used to:

(1) determine the impact of specific design features on logistic support;

(2) determine how the proposed logistic support system affects system reliability, availability and maintainability characteristics;

(3) provide input data for tradeoff analysis, life cycle cost studies, and logistic support modeling and

(4) provide source data for the preparation of logistic products including training and technical manuals, etc.

During a contract performing phase, a Government review team will regularly review the contractor's LSAR reports to ensure that support system development is adhering to the established maintenance plan and contract requirement.

2.6.3 RESPONSIBLE DEVELOPMENT ORGANIZATION

The Materiel Readiness Support Activity (MRSA) of the US Army Materiel Command was delegated major responsibilities for developing, managing, and supporting the LSA process as the DoD Lead LSA Support Activity. Mr. John Peer (AV-745-3985) is currently the program manager.

2.6.4 IMPLEMENTATION TOOLS/AIDS

1. The MIL-STD-1388-1A standard defines and details the LSA program requirements, however there was no source available to describe the procedures and techniques for LSA accomplishment. Currently, numerous methodologies exist within DoD and industry which can be used to satisfy many of the LSA task requirements. MRSA has screened and compiled a report "Logistic Support Analysis Techniques Guide" (AMC-P 700-4, March 1987) which provides a catalog of techniques, both manual and automated, currently used by DoD and industry to accomplish the LSA tasks. This Guide includes more than 100 techniques or procedures in the performance of MIL-STD-1388-1A and catalogues the techniques in order to facilitate the cross-fertilization of information and curtail the efforts to perpetually "reinvent the wheel".

2. The Air Force sponsored Unified Data Base (UDB) system focused on the development and implementation of an automated LSAR and associated technology to accommodate logistics information prepared under the provisions of MIL-STD-1388-2A. UDB provides a user-friendly automated data system that

permits on-line entry and retrieval of LSAR information. UDB is supported by the Cullinet's Integrated Database Management System (IDMS) on an IBM (OS/MVS) mainframe compatible environment. UDB is currently used by the SSN-21 program in the performance of LSAR requirements.

2.6.5 ON-GOING DEVELOPMENT ACTIVITIES

The format and data elements of the LSAR (MIL-STD-1388-2A) is being modified and extended by MRSA to include relational tables that comprise an LSAR data base. This updated standard will be MIL-STD-1388-2B. Concurrent with this effort, a new on-line DoD LSAR ADP system supported by a relational data base is being developed by Battelle and DACOM with funding provided by the OSD CALS Office. Both the updated LSAR standard and the supporting ADP system are planned for release in late 1990. It is expected that other automation tools for using MIL-STD-1388-2B will be developed by both Government and commercial users.

2.6.6 CALS DATA EXCHANGE STANDARDS

MIL-STD-1388-2 defines the format and content of the LSAR and the structure of various standard reports that allow delivery of the data in digital form. MIL-STD-1388-2 is also a technical standard for delivery of LSAR data in digital form.

2.6.7 GOVERNMENT/INDUSTRY LSA USER'S GROUP

MRSA is sponsoring a Government/Industry LSA User's Group meeting which meets annually. The first meeting was held at Wright-Patterson AFB in October 1988. The Navy contact for the meeting is Mr. Ron Golenbioski of NAVAIR Code 4111 (Tel. AV-222-0028).

2.6.8 DoD LSA NEWSLETTER AND ELECTRONIC BULLETIN BOARD

MRSA is planning to publish a Newsletter and sponsor an electronic bulletin board.

2.6.9 TRAINING

Army MRSA provides no-cost on-site training of LSA/LSAR courses. Contact point is Mr. David Morgan (AV-687-2156).

2.7 THE PRODUCT DATA EXCHANGE SPECIFICATION (PDES)

2.7.1 PURPOSE

The Product Data Exchange Specification (PDES) is being developed to capture information about a product in a computer sensible format. The targeted information is that which is needed to completely define a product, a component part or an assembly of parts over its life cycle for the purpose of design, analysis, manufacture, test, and inspection. This includes the product's geometry, topology, logistics, tolerances, attributes and features. The PDES specification is intended to one day exceed the capabilities of the existing Initial Graphics Exchange Specification (IGES) and ultimately replace that standard.

2.7.2 SCOPE

The first draft of PDES addresses the areas of: geometry; topology; shape; tolerances; materials; drafting; mechanical products; Architecture, Engineering, and Construction (AEC) (the AEC core and ship structure models); electrical; and Finite Element Modeling (FEM). These models are part of the draft proposal submitted to the International Standards Organization (ISO) for approval. The specification is currently being developed and is not yet a standard; but the draft is proceeding through the review and approval process needed to create an international standard. Some of the models within the present specification may change, or even be withdrawn from the draft proposal, depending on the results of the ISO ballot.

The direction in which PDES implementations are intended to advance is specified by the four levels of implementation. These levels specify the manner in which data is to be exchanged or shared.

Level 1: File Exchange (targeted for first version)
Level 2: Working Form Exchange/with access software (future)
Level 3: Database Exchange (future)
Level 4: Knowledge Base Exchange plus active constraint checking (future)

These concepts are being clarified by the IGES/PDES organization and are intended to create increasingly effective methods of data exchange/sharing. A Level 1 implementation exchanges PDES files in the same manner that IGES files are exchanged today. In a level 2 implementation, the data will be translated into or out of a standard working form (which may be different than the exchange format file) where it can

be accessed by a standard software program. This means that a standard software program would be used by programmers to get data into and out of the standard working form. The IGES standard does not have this feature; vendors were required to write their own software programs to access the IGES file and some vendors erroneously left out parts of the IGES file, causing problems for the system that receives the file. A Level 3 implementation, will translate the data into and out of a data base management system (DBMS). This level will allow access to the PDES DBMS by standard database languages such as SQL. A Level 4 implementation will also translate the data into and out of a DBMS, and will enforce any constraint rules specified in the PDES standard. For example, if the ship structures model states that a distribution system must be contained within the hull, the constraint rules would check to ensure that this condition is not violated.

PDES is described as having a three schema approach, the application, logical, and physical layers (or schemas). The application layer presents the user's view of product data in his particular application from his viewpoint. This view is developed and represented through graphical models specific to a given application and are developed using an information analysis methodology (i.e. IDEF1X or NIAM). All application models are mapped into the logical layer, which provides a single abstract view of the collection of application area data; similar concepts in the different application models are integrated into common general entities. The logical layer serves to shelter the application layer from the details of the physical layer (and shelters the engineer from the internal computer representation of the data). The logical layer is described using an information description language (called Express). The generic entities in the logical layer are represented in the physical layer in a machine readable form. The physical layer contains the actual file format definitions and a representation of the application's models as a sequential file in an unambiguous context-free grammar, which is suitable for processing by computer software.

2.7.3 STATUS AND PLANNED EXTENSIONS

The PDES specification is divided into a number of different chapters, which are called clauses, with a 400 page limit per clause. Most clauses are normative, the ISO expression for required, and cover the Express definitions of entities, test methods, definition of the Express language, physical file structure and the mapping of entities from Express to the physical file structure. Others are informative, meant as helpful reference material. These areas include the IDEF or NIAM information models and information on development support.

The Express language used by PDES is a formal language designed for communicating information concerning data. The language is similar to the portions of computer programming languages that declare the structure of data (as does the ADA language). Express is not intended to be used directly by the computer, but will be mapped (or compiled) into a data definition language or a programing language.

Work is underway for the future PDES version 2. The models under consideration for addition to PDES are: AEC, Electrical, Form Features, FEM, and Materials models. Other new information models being developed, but not ready for consideration are: Manufacturing, Logistics, Composite Materials, Vehicle systems, and Kinematics models.

2.7.4 PROBLEMS

The PDES specification is being developed by a volunteer organization, IGES/PDES, which causes the development effort to proceed slowly. There are problems with the continuity of individuals participating in the PDES development, dependent upon their organizations support of their PDES involvement. The specification is also working towards international standardization, which increases the time required to officially release the document. The requirements that the PDES specification is trying to meet are not clearly stated within the PDES document. The requirements are buried within various sections and within the models themselves. This increases the difficulty of determining if the specification actually meets its requirements.

2.7.5 EXTENT AND NATURE OF USER AND VENDOR SUPPORT

PDES is currently under development. The document is a draft, not yet approved by ISO, and no official PDES translators are available. A few experimental implementations of portions of the current PDES draft document have been developed, but these prototype translators will probably be quite different from the final translators because the basic specification will probably change. A prototype developed by the Chair of the Physical File Committee, Jeff Altemueller of McAir, indicates that the processing time required by PDES translators and the size of the file created will be less than that required by IGES processors and files.

There is a great deal of support for the standard within the industry community. The IGES/PDES voluntary organization is developing the specification, with a participation of 236 members at the April 1989 meeting. There is also a non-profit corporation, PDES, Inc. that has been set up to improve the

quality and to accelerate the implementation of the PDES specification.

2.7.6 STRUCTURE OF DEVELOPMENT ORGANIZATION

PDES is being developed by the IGES/PDES Voluntary Organization under the direction of the Project Manager, Tony Day of Sikorsky Aircraft UTC. The specification is being developed in a bottom up manner. Which means that the originating technical committees start the process by modeling their own area of expertise in the graphical modeling language IDEF1X or NIAM. After review and approval within the technical committee, the committee translates the models into the logical layer representation of Express. The Express Model and the IDEF1X or NIAM model are then sent to the Integration Committee, who will integrate the model with the other models in the Integrated Product Information model (IPIM). The Integration committee, along with the model owners, will resolve conflicts and ambiguities between the different models and clarify the model interfaces.

The integrated set of models is sent to the International Standards Organization (ISO). At ISO the specification goes through a formal review and balloting process with each nation casting one vote on the approval or disapproval of the specification as an international standard. The U.S. representative to ISO is the American National Standards Institute (ANSI). PDES is the name for the Product Data Exchange Specification effort within the United States; within the international community it is known as STEP, the Standard for the Exchange of Product Model Data.

ISO approved the PDES document which was submitted for ISO registration in November, 1988, as a formal Draft Proposal. The document submitted to ISO contains data models which can describe only a subset of the product data required to represent a given product and is intended to permit international review and to serve as a check point for the PDES development effort. The ISO registration does not imply approval of the specifications content, but does begin the international balloting that will produce consensus approval of the specification. The final stages of ISO standardization are the elevation of the Draft Proposal to the status of Draft International Standard (earliest possible date January 1990)and finally to International Standard (earliest possible date January 1991). The approved PDES version 1.0 standard will most likely be a subset of the Draft Proposal.

2.7.7 TESTING AND VALIDATION

The various technical committees within the voluntary organization conduct "walk throughs" and test their own models internally, but there is currently no formal test that the models must pass before release to the integration committee. There is no designated committee in the voluntary PDES group that tests and validates the models before they are released. The non-profit group, PDES, Inc., does have a test and validation team for the models. The models currently being tested by PDES, Inc. are the geometry and topology models. The Product Structure Configuration Model (PSCM) and tolerance model are being placed under PDES, Inc. configuration control prior to being sent to their test and validation team. The shape interface model was sent back to the voluntary organization with the request that it be reworked. The results of the PDES, Inc. testing are returned to the IGES/PDES voluntary organization, where any errors or inconsistences are addressed.

2.7.8 REFERENCE AND IMPLEMENTATION DOCUMENT AVAILABLE

The PDES draft proposal can be ordered from the National Technical Information Service (NTIS) at $169.95 for a paper copy and $50.50 for a microfiche copy. Use the number PB 89 144 794 to reference the document. Order from:

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Telephone: (703)487-4650

Other documents that provide more information about PDES/STEP are:

- Outline of the Integrated Product Information Model and Express, Nigel Shaw and Jon Owen, Dept. of Mechanical Engineering, University of Leeds, Leeds LS2 9JT, United Kingdom, December 1988. (A description of the Express language and a discussion of the IPIM (Integrated Product Information Model) and its integration.)

- PDES Initiation Activities, A Reporting of the PDES Initiation Activities, Brad Smith, National Institute of Standards and Technology, May 20, 1986. (This report is a summary of the PDES activities between November 1984 through April 1986. This

document would be useful for background and historical information.)

- Welcome to the Initial Graphics Exchange Specification/Product Data Exchange Specification, Bradford Smith, National Institute of Standards and Technology, January, 1989.
  (An introduction to the IGES/PDES Organization with history of the group, the scope and plans of the technical committees, and titles of the committee reference documents.)

2.8 ELECTRONIC DESIGN INTERCHANGE FORMAT (EDIF)

2.8.1 PURPOSE

The Electronic Design Interchange Format (EDIF) is intended for the "information transfer at all levels of electronic design... from design capture and verification through layout, manufacture, and test of printed circuit boards and application-specific integrated circuits". (Exchange Standards for Electronic Product Data, M.L. Brei). EDIF handles partial and complete design data and is a public domain, machine readable format. EDIF is one of the candidates for the exchange of electronic product definition data in the Computer-Aided Acquisition and Logistic Support (CALS) effort for inclusion in CALS phase 1.2.

2.8.2 SCOPE

EDIF version 2.2.0 covers the areas of integrated circuit (IC) and printed circuit board (PCB) layouts, schematics, documentation and physical design rules. It is also being used for very large-scale integration (VLSI) design. EDIF is not intended to cover 3D mechanical drawings and analyses, system manufacturing information or other system design functions. Unlike the (Very High Speed Integrated Circuit) VHSIC Hardware Description Language (VHDL), EDIF is a non-executable data format, an ASCII data file. EDIF also has international appeal, having been accepted for use in data exchange by the European electronics community.

2.8.3 STATUS AND PLANNED EXTENSIONS

One of the design intents of EDIF was to make the specification easily extendable, this is accomplished through the use of keywords in the format. New abilities are added to the specification by the definition of new keywords.

There has been concern expressed over the number of standards for the exchange of electrical product data. A meeting, chaired by Mr. S.L.S. Barnes of the British Standards Institution, was held to discuss the boundaries of EDIF and the Product Data Exchange Specification (PDES) and an attempt is being made to harmonize the standards which apply to electronic product data.

2.8.4 EXTENT AND NATURE OF USER AND VENDOR SUPPORT

EDIF was originally designed for the exchange of semi-custom design data between designers and foundries. The development organization was formed in November, 1983, because of several companies dissatisfaction with existing data

exchange formats for Integrated Circuit (IC) designs. The electronics companies that developed the original specification are Texas Instruments, National Semiconductor, Motorola, the University of California at Berkeley, Tektronix, Daisy Systems, and Mentor Graphics.

EDIF is widely accepted within the European communities. Extensive user groups have been formed in Britain, West Germany and Japan.

2.8.5 STRUCTURE OF DEVELOPMENT ORGANIZATION

The EDIF organization is an ad hoc voluntary consortium composed of members from industry and academia. The organization is guided by a steering committee which makes the needed policy decisions. Next in the hierarchy is the Technical Committee, which coordinates the work of the technical subcommittees and holds responsibility for the technical content of the specification. Then there are the technical subcommittees, which are composed of the technical specialists who make recommendations to the Technical Committee and do the technical work. One of the primary goals of the EDIF organization is to be able to release a specification quickly, to be able to respond to the changing needs of the electrical industry.

2.8.6 REFERENCE AND IMPLEMENTATION DOCUMENTS AVAILABLE

Electronic Design Interchange Format, The EDIF User's Group, Design Automation Department, Texas Instruments, PO Box 225474, MS3668, Dallas, Texas 75265

Exchange Standards For Electronic Product Data, Information For Defense Analyses (IDA) Memorandum Report M-434, October 1988, prepared for the Office of the Assistant Secretary of Defense.

2.9 VHSIC (VERY HIGH SPEED INTEGRATED CIRCUIT) HARDWARE DESCRIPTION LANGUAGE (VHDL), IEEE 1076-1988

2.9.1 PURPOSE

The VHSIC Hardware Description Language (VHDL) is an Institute of Electrical and Electronics Engineers (IEEE) standard, IEEE 1076-1988, for behavioral models of electronic components. Very High Speed Integrated Circuit (VHSIC) designs can be created in VHDL and then exchanged between computer systems. VHDL is similar to a general computer programming language, in that it can be output once a model is developed and then compiled or interpreted into another system. It is one of the candidates for the exchange of product definition data for electronics, in CALS phase 1.2.

2.9.2 SCOPE

VHDL addresses system level design, simulation of the system and testing of the system. It is made up of three different "views" of the model: the behavioral view, the structural view and the data flow view. The behavior view is an algorithmic description of the model, (it is the part like a programming language). The structural view is a simple netlist description of the component. And the data flow view describes a network of signals and transformers.

2.9.3 STATUS AND PLANNED EXTENSIONS

The full VHDL standard is very large, its sheer size makes full implementation difficult and time consuming. This raises the possibility its implementations may be done in the same manner as occurred with the IGES standard, where every vendor implemented his own unique subset of the standard. Subsets are being proposed for VHDL to help speed implementation and aid full data exchange. One proposed subset is a design exchange subset, which "provides for the movement of behavioral, functional and gate-level models between simulators, as well as component and netlist data for CAD tools". Another proposed subset is the core subset that "permits minimal functional format translation, without timing or concurrency data" (February, 1989 Computer Design). These subsets are being developed by the VHDL Design Exchange Group, lead by Mo Shahdad, president of CAD Language Systems, Inc.

The Electronics Industries Association (EIA) plans to develop standards for behavior simulation models written in VHDL (VHSIC Hardware Description Language). According to the EIA, "Initial emphasis will be to provide defense electronics

contracts with the ability to comply with DoD regulations concerning the delivery of contractual data in digital form" (February 1989, CAD Report).

2.9.4 PROBLEMS

VHDL simulators need basic component model libraries in VHDL of standard components to realize the simulators true productivity, but the cost of developing these libraries is high. An estimate of $15 to $30 million was given in the CALS Report, February 1989. Component models are developed and often marketed by third party companies. With a neutral standard, there is concern that these models can be easily "pirated". The VHDL Ad Hoc Committee of the Electronics Industries Association (EIA) is proposing a solution to this problem with the concept of an industry consortium to share the cost of developing VHDL models.

While the standard defines the syntax, there are few rules for how models should be created in VHDL. When there are discrepancies between two VHDL descriptions "there's no means to validate which description is correct" - Feb. 1989 Computer Design.

2.9.5 EXTENT AND NATURE OF USER AND VENDOR SUPPORT

Mentor Graphics has announced the first full implementation of IEEE STD-1076 with their software product System-1076, in February 1989. They chose VHDL because "First, VHDL supports multiple levels of abstraction, so it maps very well into the way a designer thinks and works. Second, VHDL is the industry-standard hardware description language", according to Geoff Bunza, general manager of Mentor's design and analysis division. Their product will be available in the 3rd quarter of 1989.

Other vendors that support VHDL are Vantage Analysis with a schematic to a VHDL simulator named the Electronic Spreadsheet. Silicon Compiler Systems and Intermetric both provide compiled data simulators. These compile the VHDL file into the companies own simulator database.

There are many other hardware description languages (HDLs) already existing within industry. Some of these were created by adding extensions to computer programming languages, while others are special languages that contain data structures for some electronic hardware such as a register, Random Access Memory (RAM), and Read Only Memory (ROM). But none of these HDLs have reached the status of a national standard as VHDL has.

2.9.6 STRUCTURE OF DEVELOPMENT ORGANIZATION

VHDL was started by the Air Force through the Very High Speed Integrated Circuit (VHSIC) Program Office. A team of Intermetrics, IBM and Texas Instruments formed the initial draft of the language. It was sent to the IEEE for approval as a national standard. IEEE Design Automation Standards Subcommittee (DASS) is now maintaining the language.

2.9.7 REFERENCE AND IMPLEMENTATION DOCUMENTS AVAILABLE

IEEE VHDL 1076-1988, the VHDL standard.

MIL-STD-454, applies to all electronic equipment. Copies may be ordered from: Department of Defense Single Stock Point, Commanding Officer, Naval Publications and Forms Center (NPFC), 5801 Tabor Avenue, Philadelphia, PA 19120.

Exchange Standards for Electronic Product Data, Information for Defense Analysis (IDA) Memorandum Report M-434, October 1988, prepared for the Office of the Assistant Secretary of Defense.

The Electronic Industries Association (EIA) is developing a set of standards expected to be available in 1989:

- EIA VHDL Commercial Component Model Specification
- EIA VHDL Blank Detail Specification
- EIA VHDL Timing Module Specification
- EIA Engineering Practices for Quality Assurance of Standard Part Models

These standards will be available through the Electronic Industries Association, 2001 Eye Street, N.W., Washington,D.C. 20006.

2.10 OFFICE DOCUMENT ARCHITECTURE (ODA), ISO 8613

2.10.1 PURPOSE

The two chief purposes of ODA are to facilitate document interchange such that:

(1) Different types of content (i.e. text, raster graphics, vector graphics, data, photographic images, etc.) can all appear in a document and be transferred easily to another computer system with another operating system.

(2) Requirements of editing, formatting, and internal storage can be communicated in the same file of information, but the emphasis is on transfer of layout information which is what ODA terms as document "architecture."

ODA allows the sharing of text between or among systems in which documents have been composed using any standard character set, or raster graphics based on the International Consultative Committee on Telegraphy and Telephony (CCITT) (an international standards organization), or vector graphics based on the Computer Graphics Metafile (CGM). ODA works with the layout of a document with its specified format, and is not concerned with such logical elements as titles, heads, subheads, and paragraphs, but only with the content of the document, represented as strings of character data. ODA provides, to a limited extent, for the preservation of a document's structure, but is much weaker in this function than is the Standard Generalized Markup Language (SGML). The role of ODA with respect to CALS has not been fully defined. In MIL-STD-1840A and MIL-M-28001 there are references to ODA which allow the possible future inclusion of ODA as a CALS standard.

ODA provides for the representation of documents in three forms:

(1) Formatted form in which documents are presented (output) as intended by the originator.
(2) Processable form in which documents may be edited and formatted by the recipient.
(3) Formatted processable form which allows documents to be presented and/or edited and reformatted.

2.10.2 TYPICAL APPLICATIONS

ODA is especially useful for processing one-time documents in which the preservation and conformance of a

logical structure is not critical. ODA was initially developed for the processing of office type documents.

ODA provides for the representation of documents containing various types of content including character data, raster-scanned images, and vector graphics, all of which conform to international standards.

2.10.3 STATUS

ODA is defined by an international standard, which is currently competing with SGML and its extensions to become the preferred system for Computer Aided Logistics Support (CALS) technical publications. Despite ODA's development by academia and industry, it has received less attention from the CALS community than has SGML. ODA provides few attributes for representing logical structure, nor does it provide a "parsing" capability. It should be noted that by making SGML the CALS standard for exchange of technical publications, DoD has decided that logical structure of technical publications is a requirement. By using SGML, compliance of the logical structure can be ensured.

2.10.4 PLANNED EXTENSIONS

ISO, in conjunction with CCITT, is working on future extensions to ODA, including the following:

* Document access and manipulation functions, which will provide support for applications such as remote document editing and data entry.

* Manipulation of color information.

* The use of data in documents to be used in applications such as spreadsheets, processable tables, and business graphics.

* The inclusion of security features.

* The addition of annotations and the control of document revision.

* The inclusion of audio and voice information.

* Enhanced layout features.

CCITT has recently approved a new series of communication protocols to be used in conjunction with their T.410 series of Recommendations. These new protocols (T.430) will be used

with the T.410 series as the basis of further document interchange services that will be developed during the next study period (1989- 1992).

Subsets of ODA standards, referred to as document application profiles (DAPs), are being developed by several users. DAPs will be documented by various standards-making organizations, eg., ISO and CCITT, and included will be information about how these DAPs are to be used. Other publications will define equipment characteristics and communication requirements for these services.

Several user/manufacturer groups are now developing a hierarchically related set of DAPs that will make possible the interchange of documents ranging from simple text documents to highly-structured multi-media documents containing text and graphics, including documents produced with desk-top publishing systems. International groups are involved in this effort and joint meetings are being held to clear up differences.

Important initiatives are going on in both Europe and in the USA. The EXPRES (Experimental Research in Electronic Submission) project is underway in the USA, with Carnegie Mellon University and the University of Michigan as the main participants. These initiatives are designed to demonstrate the interchange of information among different proprietary systems by the use of ODA. Developers also want to produce document editing systems and, thus, further enhance ODA's capabilities.

2.10.5 DEVELOPMENT ORGANIZATION

ISO is the development organization of ODA and there are two methods in which changes may be made to the standards:

(1) A "defect report" can be issued to ISO-member organizations (ANSI in the USA) by a user, following which a proposed solution is promulgated by that organization.

(2) Extensions to the standard can be issued directly by a part of the International Standards Organization (ISO).

2.10.6 TESTING AND VALIDATION

ODA has been tested and documented by both ISO and CCITT as of early 1988. As future extensions are implemented, they

and their interfaces with the existing ODA system will have to be tested.

2.10.7 REFERENCE AND IMPLEMENTATION DOCUMENTS

ISO 8613, "International Processing: Text and Office Systems-Office Document Architecture (ODA) and Interchange Format," Parts 1-8 is very theoretical and requires careful reading. The CCITT approved a series (T.410) of recommendations also in 1988, "Open Document Architecture (ODA) and Interchange Format," the contents of which are nearly identical to those of ISO 8613. Further, ECMA published a standard in 1985, "ECMA-101," which explains both formatted and processable type documents. The document has been used as a basis for developing prototypes of ODA-based systems. "Document Transfer and Manipulation (DTAM): Service and Protocols," a new set of communication protocols was published as the CCITT T.430 series of Recommendations in 1988.

2.10.8 SUMMARY

ODA is an international standard which facilitates the computer interchange of documents in both revisable ("processable") and final ("formatted") forms. ODA allows computing systems of different manufacture to have a common understanding of the semantics of interchanged documents.

2.11 CALS STANDARDS SUMMARY

The following charts identify each current and future CALS data interchange standard described and relates these CALS standards to their intended applications.

Chart 1. CURRENT CALS DATA EXCHANGE STANDARDS

DoD Standard	Applications	Description
MIL-D-1840A	Tech Pubs and Product Data	Provides rules for organizing files of digital data for a complete deliverable document
MIL-D-28000, IGES	CAD, Vector Graphics - Engrg Drawings - TM Illustrations (optional) - Elec Applications - NC Manufacturing	Data is transferred as a set of entities with associated non-geometric data
MIL-M-28001, SGML	Automated Publishing - Tech Manuals	Basic structure of a text document is transferred by using a set of mark-up tags
MIL-R-28002, Raster	Raster Scanned Images - Engrg Drawings - TM Illustrations	Raster images stored as a series of lines consisting of arrays of dots.
MIL-D-28003, CGM	Vector Graphics - TM Illustrations (preferred)	Illustration data is transferred in vector format.

Chart 2. FUTURE CALS DATA EXCHANGE STANDARDS

Standard	Application
LSAR Logistic Support Analysis Record	MIL-D-1388 Being Revised to Facilitate Logistic Support Use of Relational DBMS Technology
PDES Product Data Exchange Specification	Complete Product Definition for Applications Over Life Cycle
EDIF Electronic Data Interchange Format	Electronics Product Definition
VHDL VHSIC Hardware Description Language	Electronics Product Definition
ODA Office Document Arch and Interchange Format	Presentation and Layout - Technical Publications

3.0 OVERVIEW OF SELECTED INDUSTRY APPROACHES TO DIGITAL DATA EXCHANGE

This section provides a brief overview of selected industry approaches to digital data exchange. It is not intended to represent a complete description of any company's activities but rather to provide an insight into each company's recognition of the importance of digital data exchange and their approach to addressing the problem. The companies highlighted are McAir, Newport News Shipbuilding, Northrop Aircraft Division, and Westinghouse Electronic Systems Group.

3.1 OVERVIEW OF McAIR'S APPROACH TO DIGITAL DATA EXCHANGE

3.1.1 CORPORATE OBJECTIVE

McAir has made a corporate commitment to advancing and improving product data exchange practice by means of data sharing and standards. McAir's goal is to improve weapon systems affordability by managing information as a critical resource to design, manufacture, and support the product using advanced information technology.

3.1.2 STRATEGY TO ACCOMPLISH THE OBJECTIVE

McAir's strategic vision to accomplish this goal is through R&D efforts in information modeling and digital exchange technology, and through the use of a shared data base which can be accessed by design and manufacturing engineers, logisticians and for technical manuals, and computer based training, etc.

3.1.3 APPROACH

The McAir approach to achieving this objective is:

- to participate in digital data exchange standards development efforts,
- to develop enabling technology,
- to develop prototype digital product model
- to proceed towards integrating the work processes within their company.

3.1.4 MAJOR ACTIVITIES IN SUPPORT OF APPROACH

Product Definition Data Interface (PDDI) - PDDI is an Air Force sponsored R&D project which was initiated in 1982 and completed in 1987. The PDDI project demonstrated a prototype system targeted at the functional replacement of engineering drawings with the development of a complete digital part model to serve as an interface between engineering, manufacturing and logistic support. In the PDDI project, the shared data base provides an integrated product definition between engineering operations, customers, and suppliers and through a translator provides an exchange medium to another company. The EXPRESS language used in PDES is an outgrowth of the PDDI project.

Product Data Exchange Specification (PDES) - McAir has been actively involved in the development of PDES since its inception. The technology in PDES was partially derived from

McAir's Product Definition Data Interface (PDDI) project. McAir has contributed to the PDES standard development effort through its technical expertise in digital data exchange and chairmanship of PDES standards development subcommittees such as drafting, logical layer, manufacturing, physical layer, and technical publications.

Jerry Weiss of McAir is the convener of the international PDES/STEP committee. McAir has accepted a leadership position in PDES, Inc. and is one of its charter members.

Geometric Modeling Applications Interface (GMAP) - The objective of this R&D project is to identify and organize the geometric and nonshape data needed for the engineering, manufacturing, and logistics support of complex structured components; and demonstrate a digital technology for the communication and manipulation of such data for turbine blades and disks. The McAir's contribution, as a subcontractor, of GMAP include the following: the definition and modeling of product data for engine blades and disks, a survey of geometric modeling, and the demonstration of the integration of a prime contractor's development efforts and products with both the vendor's and the Air Force's Logistics Center depot systems.

Data Product Model (DPM) - The PDDI developed technology is being applied to the development of a digital product model for use on the Air Force Advanced Tactical Fighter (ATF) with the goal of establishing a methodology to replace ATF drawings with electronic digital data. The Statement of Work for the ATF/DPM calls for constructing digital product models, demonstrating the transportability of the models, demonstrating the applicability of digital product data, evaluating cost/benefits and potential problems, and recommending an evolutionary path for Air Force data acquisition policies. This ATF/DPM project is scheduled for completion in 1991 at which time an ATF/PDES project will be initiated.

3.2 OVERVIEW OF NEWPORT NEWS SHIPBUILDING APPROACH TO DIGITAL DATA EXCHANGE

3.2.1 CORPORATE OBJECTIVE

Newport News Shipbuilding (NNS) is one of the navy's leading shipbuilders. As a Navy prime contractor for nuclear-powered aircraft carriers and submarines, two of the most complex and expensive weapons systems in existence, NNS developed extensive in-house CAD/CAM and integrated logistic support capabilities. The designing of the advanced submarine, SSN-21, is being jointly developed by both NNS and General Dynamics/Electric Boat Division (GD/EB), digital data sharing between these two corporations and their subcontractors has become a necessity.

In order to become more competitive and achieve business performance improvement, NNS has committed themselves to the development and implementation of a product model, the automation of integrated logistic support, and the development of an integrated publishing system for use on the SSN-21.

3.2.2 STRATEGY TO ACCOMPLISH THE OBJECTIVE

The strategy to accomplish the objective is:

- to capture digital data early in the design phase and to develop a 3-D digital product model for ship's engineering data,
- to produce LSA concurrently with engineering design,
- to promote the modernization of the infrastructure that will create, receive, review, store, and use those digital data products,
- to relieve the in-house data exchange problems by adapting primarily IBM computing equipment,
- to develop digital data exchange capabilities with outside vendors,
- to proceed towards integrating the work processes within their company, and
- to participate in digital data exchange standards development efforts in IGES/PDES and in the Navy/Industry Digital Data Exchange Standards Committee (NIDDESC).

3.2.3 APPROACH

SSN-21 is the only new ship design by NNS since the early 1970's. Nevertheless, NNS's approach to implementing CALS technology is not intended to fundamentally change the way a ship is designed. It is intended to capture the data that is developed as a natural part of the ship design and shipbuilding process and to establish key relationships among the data that ensure functional integration of information systems and processes. *This is intended to reduce and* eliminate the need for multiple iterations of data in redundant files, reduce the volume and cost of deliverables, and improve the quality, accessibility, and responsiveness of the data that creates the deliverables.

The ship product data model is to create a single geometric description of the ship "as designed" and "as built". The main advantage of the three dimensional modeling technique is the ability to create an item only once and retain only sufficient attributes to physically describe the item within the model context. These items are then related to the specifications, standards, documents, and other technical data that define the item. Establishment of these relationships support the integration of the engineering, configuration, and logistic data.

* Product Data Model and VIVID Database:

The development and maintaining of the geometric description of the ship is referred to by NNS as the "Product Data Model" which is produced by 174 work stations (IBM/CADAM) for drafting, structural design, and performing stress analysis. This Product Data Model is stored in the CADAM 2D and CADAM 3D databases. Also there are 41 solid modeling work stations (Lexidata/Graphicon) used for outfitting modeling in VIVID. VIVIL incorporates an interactive solid display for component modeling and arranging of distributive systems in the ship. In addition, there are two ComputerVision (CV) systems at NNS supporting 8 to 10 work stations. These CV systems are used primarily for NC shape cutting of sheet metal and manufacturing of machinery items. Interfaces between CADAM 2D, CADAM 3D and VIVID have been developed and the IBM Internal Format (IIF) is used for internal exchange between systems within NNS.

An Electronic Design Release Center has been established at NNS as the place for the storage of the approved for released version of the digital data drawings and for the controlling of the digital drawing release process.

* Integrated Logistic Support:

NNS is building an interim and partial system of SEAWOLF Automated Integrated Logistic Support System (SAILSS) to meet the ILS schedule for SSN-21. The functional specifications for SAILSS is currently being developed and is being designed to integrate design data with logistic data as well as to ensure data continuity between the acquisition and operational phases of the ship-class. The Expanded Ship Work Breakdown Structure/Function Group Code (ESWBS/FGC) which permits integration and interaction with respective technical and logistic information will be the common data link between SAILSS and other logistic subsystems; it will maintain this identity across each hull of the class. SAILSS will produce SEAWOLF logistics products such as maintenance plans, training curricular and repair standards over the class life cycle. SAILSS will be a composite of individual subsystems, linked by on-line software programs, common data elements and a telecommunications network and will be centralized at the lead design yard and will be available to remote user work stations through telecommunication lines.

* Digital Data Exchange:

Extensive digital data exchange capability has been established between NNS and GD/EB. The following table lists the current situation:

TYPE OF DATA	INTERFACE	STATUS	GUIDELINE	FREQUENCY
2-D Drawing	IGES 3.0 Magnetic tape	Production	PMS 350 DDEP-001 DPMC-007	Upon request
3-D Structure Magnetic tape	IGES 3.0	Production	PMS 350 DPMS-004 DPMC-007	100%
3-D Piping design	IGES 4.0 Magnetic tape	Final Test 7/89	PMS 350 DDEP-005 DPMC-007	100%
Non-processable text	Wang OSI on disk	Production	PMS 350 DDEP-006	Upon request
Processable text	EBCDIC Magnetic tape	Production	PMS 350 DED-002 DED-003	Regularly/ Upon request

3.3 OVERVIEW OF NORTHROP'S APPROACH TO DIGITAL DATA EXCHANGE

3.3.1 CORPORATE OBJECTIVE

Northrop has made a corporate commitment to advancing and improving product data exchange practice by means of data sharing and standards. Northrop's goal is to improve weapon systems affordability by managing information as a critical resource to design, manufacture, and support the product using advanced information technology.

3.3.2 STRATEGY TO ACCOMPLISH THE OBJECTIVE

The Northrop Aircraft Division has developed a strategic plan known as the Northrop Aircraft Division Strategic Architecture Plan (NADSARP) for future capabilities. Since the completion of the NADSARP document in 1986, only projects which fit the NADSARP architecture are approved. The key element in Northrop's transition from product development to production is the Product Definition Development Center (PDDC) concept which is a commitment to change in ways to design, plan, and support the products and is a strategy that defines the weapon system from a common data base, providing the product definition, delivery and support with simultaneous access to product information.

3.3.3 APPROACH

The Northrop approach to achieving this objective is:

- to participate in digital data exchange standards development efforts,

- to develop enabling technology,

- to implement the Product Definition Development Center concept, and

- to proceed towards integrating the work processes within their company.

3.3.4 MAJOR ACTIVITIES IN SUPPORT OF APPROACH

Product Definition Development Center (PDDC) - PDDC is not a place but a concept where people, processes and automated tools work together as a product definition team. The functioning of PDDC results in the concurrent, active involvement of technical personnel in all product definition disciplines (design and analyses, manufacturing, material,

quality assurance and logistics support personnel), to create a digital product definition. The initial implementation of the PDDC concept is operating in the Advanced Tactical Fighter (ATF) Prototype Program. The Full Scale Development (FSD) Program of ATF is much more complex than the ATF Prototype Program environment. The following two projects for PDDC concept implementation which relate to digital data sharing are being developed for the ATF/FSD Program:

1. PDDC Shared Data Base - The goal is to develop and implement a single shareable product definition data base in which all users and applications add value or query the information that composes the product definition which includes engineering, manufacturing, and ILS data. The completion of the this Shared Data base is expected by the end of 1990.

2. Integrated Configuration and Management System (ICMS) - ICMS is the aggregate of and the linkage of the manual and automated systems (business, text, graphics and geometry) that are used during the requirements, definition, implementation, verification, and compliance phases to ensure traceability from the specification requirements to the product configuration throughout the product life cycle. ICMS interfaces to the various organizations, subcontractors and suppliers that make a functional contribution to product definition.

Product Data Exchange Specification (PDES) - Northrop has been actively involved in the development of PDES. Northrop has contributed to the PDES standard development effort through its technical expertise in digital data exchange and leadership to the standard development effort. Northrop is a member of the PDES, Inc.

Data Product Model (DPM) - The DPM is an Air Force contracted demonstration and feasibility study, aimed at replacing engineering drawings with electronic digital data and providing proof-of-concept for PDES. The use of DPM's during the Advanced Tactical Fighter (ATF) full scale development is expected to contribute significantly to the CALS initiative by providing an integrated database for product definition. The DPM effort comprises three major initiatives:

- data modeling to define the complete geometric definition,

- demonstrations of PDES Level 2 (active file exchange) to be conducted at McAir, and Level 3 (shared database access) to be conducted at Northrop, and

- evaluating cost/benefits and potential problems, and recommending an evolutionary path for Air Force data acquisition policies.

This ATF/DPM project is scheduled for completion in 1991 at which time an ATF/PDES project will be initiated.

3.4 OVERVIEW OF WESTINGHOUSE'S APPROACH TO DIGITAL DATA EXCHANGE

3.4.1 CORPORATE OBJECTIVE

Westinghouse Engineering Electronic Systems Group (ESG) employs more than 30,000 workers and has engineering, manufacturing, and maintenance offices and factories throughout the United States and many foreign countries. ESG has a diversified business with the Government, and produces a variety of consumer products. In order to achieve business performance improvement, ESG has committed themselves to the development and implementation of an integrated information system to manage, control, and integrate engineering data, processes and processing hardware.

3.4.2 STRATEGY TO ACCOMPLISH THE OBJECTIVE

The strategy to accomplish the objective is the development of the Westinghouse Integrated Systems for Engineering (WISE) project. WISE is an information system which is currently being developed to integrate Westinghouse's Electronic Systems Group's heterogeneous CAD/CAE/CAM environment, and to support a concurrent engineering initiative. WISE will capture information early in the life cycle and will facilitate:

- downstream use of data,
- consistent life cycle configuration management,
- distribution of data to support local applications, and
- inter-organizational use and management of data.

Since 1987, ESG has been developing the WISE prototype system. If the development is successful, WISE will be expanded to support Westinghouse nation-wide and it may become a commercial product. A demonstration of the WISE prototype is scheduled in early 1990.

3.4.3 APPROACH

The backbone of WISE is the implementation of a distributed processing and integrated network architecture which will:

- provide a fault-tolerant distributed processing environment nation-wide linking WISE local-nodes,

- provide local WISE network-node services which will achieve integration of heterogeneous CAD/CAE/CAM environments (a WISE local node may be installed anywhere in the world),

- establish an interactive product life-cycle design support environment for group technology and concurrent engineering, and

- establish configuration controlled document release and electronic vault mechanisms for both magnetic and WORM storage.

4.0 IDENTIFICATION OF NAVY ISSUES ACTIVITIES TO BE INCLUDED IN PART II

The next step, part II, in approaching a Navy digital data exchange strategy will be to review the data exchange activities/approaches associated with the following on-going Navy weapons systems: SSN-21, DDG-51, A-12, V-22, and the MCM Product Model. These weapons systems development efforts are expected to provide input to the strategy by investigating the approaches taken by these programs in integrating their data bases for CAD, CAM, engineering and logistics analyses and how they generate and transfer drawings, technical manuals, training materials, supply data, and other products in digital form.

In addition to investigating these Navy weapons systems data exchange activities, other services approaches to digital data exchange will be investigated.

The information gathered in this step will provide the necessary input to develop a coherent Navy-wide strategy for digital data exchange of logistics technical information.

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